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(54) Tetraphenylthiophene derivative and electrophotographic photoreceptor containing same.

(57) There are here provided a novel tetraphenylthiophene derivative represented by the general formula

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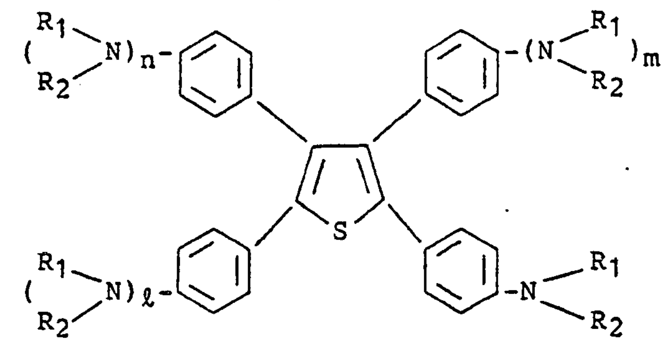

wherein each of R_1 and R_2 is an alkyl group, an aralkyl group or an aryl group which may be substituted, and R_1 and R_2 may be linked with each other to form a ring together with a nitrogen atom; and each of ℓ, m and n is an integer of 0 or 1 and is selected to meet the condition formula $\ell \geq m \geq n$;
and an electrophotographic photoreceptor which is composed of an electrically conductive base and a photosensitive layer thereon containing the aforesaid tetraphenylthiophene derivative as a charge-transporting material, and a charge-generating material, preferably a specific azo compound.

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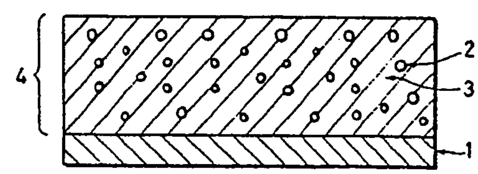


Tetraphenylthiophene Derivative and Electrophotographic Photoreceptor Containing Same

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a novel tetraphenylthiophene derivative and an electrophotographic photoreceptor containing the derivative. More specifically, it relates to an electrophotographic photoreceptor in which a novel tetraphenylthiophene derivative is contained as a charge-transporting material in a photosensitive layer on an electrically conductive base.

(2) Description of the Prior Art

Heretofore, as photosensitive materials for electrophotographic photoreceptors, there have been widely used inorganic photosensitive materials such as selenium, cadmium sulfide and zinc oxide. However, the photoreceptors using such photosensitive materials do not sufficiently satisfy requirements for the electrophotographic photoreceptors such as sensitivity, light stability, moisture-proofness and durability. For example, the photoreceptors using selenium materials have excellent sensitivity but are liable to crystallize owing to heat or contaminants, so that characteristics of the photoreceptors deteriorate. In addition, this type of photoreceptors have many drawbacks. That is, manufacturing cost is high because of the utilization of vacuum evaporation, and it is difficult to mold them into the form of a belt because of less flexibility. The photoreceptors using the cadmium sulfide material are poor in moisture-proofness and durability. Furthermore, the photoreceptors in which zinc oxide is used have unsatisfactory durability.

Now, in order to eliminate these disadvantages of the photoreceptors using the inorganic photosensitive materials, various photoreceptors based on organic photosensive materials have been investigated.

Of the photoreceptors developed to remove the above-mentioned drawbacks, function-separated photoreceptors have been recently noticed in which a charge-generating function and a charge-transporting function are separately allocated to different materials. In the function-separated photoreceptors, materials having various desirable functions can be selected from a wide range of materials and combined with one another, which permits preparing the photoreceptors having high sensitivity and sufficient durability.

Requirements for the charge-transporting material contained in the electrophotographic photoreceptor are as follows:

(1) Possessing sufficiently high ability to receive electric charges generated from the charge-generating material.

(2) Being capable of promptly transporting the received charges.

(3) Being capable of successfully transporting the charges even in low electric field so that no charges remains.

In addition, the photoreceptor should be stable to light and heat during the repeating operation of electrification, exposure, development and transfer, and should have durability enough to obtain faithfully reproduced copy images.

As the charge-transporting materials, various compounds have been reported. For example, poly(N-vinylcarbazole) is known as a light-conductive material for long time, and the photoreceptors in which this compound is used as the charge-transporting material have been put into practice. However, this type of photoreceptors are poor in flexibility and are brittle, with the result that cracks easily take place. This fact means that their durability is so bad as not to withstand the repeating use. Furthermore, when the flexibility is improved by the use of a binder, electrophotographic properties deteriorate inconveniently.

A low-molecular weight compound has no coating properties, and thus when a photosensitive layer is formed, such a compound is mixed generally with a binder in an arbitrary ratio. Now, many charge-transporting materials have been suggested which comprise low-molecular weight compounds. For example, hydrazone compounds have high sensitivity as the charge-transporting material (see Japanese Patent Publication Laid-open Nos. 55-46761, 55-52064, 57-58156 and 57-58157). However, these compounds tend to decompose by ozone generated during corona discharge and are unstable to light and heat. In addition,

when this kind of charge-transporting material is used, obtained images are poor in contrast or have much fog owing to the degradation of charge retensiòn ability by the repeating use or owing to the accumulation of residual potential, though initial performance is good.

Other many charge-transforming materials have been suggested, but those which sufficiently satisfy the practical requirements for use in the electrophotographic photoreceptor are not present yet, and the development of more excellent photoreceptors is desired.

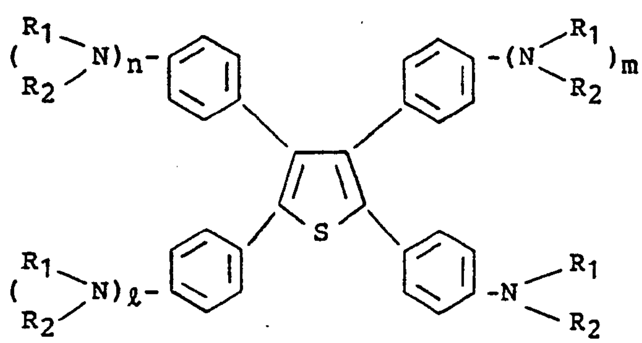
SUMMARY OF THE INVENTION

An object of the present invention is to provide a novel compound which is useful as a charge-transporting material.

Another object of the present invention is to provide an electrophotographic photoreceptor having sufficient sensitivity and excellent durability.

These objects of the present invention can be achieved by the following tetraphenylthiophene derivative and electrophotographic photoreceptor:

The tetraphenylthiophene derivative is represented by the general formula (I)



(I)

wherein each of R_1 and R_2 is an alkyl group, an aralkyl group or an aryl group which may be substituted, and R_1 and R_2 may be linked with each other to form a ring together with a nitrogen atom; and each of n, m and ℓ is an integer of 0 or 1 and is selected to meet the condition formula $\ell \geq m \geq n$.

The electrophotographic photoreceptor comprises an electrically conductive base and a photosensitive layer thereon containing the tetraphenylthiophene derivative represented by the general formula (I) as a charge-transporting material.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 and 2 are sectional views illustrating constitutional examples of electrophotographic photoreceptors.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the above-mentioned general formula (I), examples of R_1 and R_2 include alkyl groups, which have 1 to 8 carbon atoms and which may be branched, such as a methyl group, an ethyl group, an isopropyl group, a butyl group and an octyl group; aralkyl groups, which have 7 to 10 carbon atoms in all and 1 to 4 carbon atoms on an alkyl moiety, such as a benzyl group and a phenethyl group; and aryl groups such as a phenyl group which may be substituted and a naphthyl group which may be substituted.

In case that R_1 or R_2 is the aryl group, examples of its substituent include halogen atoms; alkyl groups having 1 to 8 carbon atoms such as a methyl group, an ethyl group, a butyl group and an octyl group; alkoxy groups having 1 to 5 carbon atoms such as a methoxy group, an ethoxy group and a butoxy group;

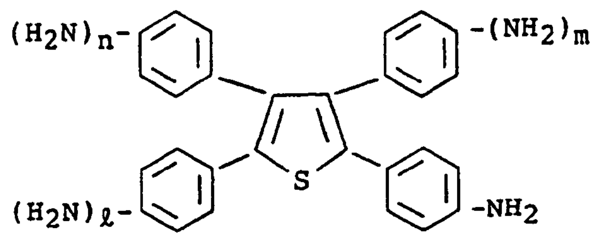
carboxylate groups having 1 to 6 carbon atoms such as a carbomethoxy group and a carboethoxy group; aralkyl groups having 7 to 10 carbon atoms such as a benzyl group and a phenethyl group; and aryl groups such as a phenyl group and a naphthyl group.

Examples of the group in which R_1 and R_2 are linked with the nitrogen atom to form the ring include a pyrrolidino group and a piperidino group.

Preferably, R_1 and R_2 both are the aryl groups, since they give compounds which have high sensitivity and are excellent in solubility in organic solvents.

The compound represented by the above-mentioned general formula (I) can be synthesized by, for example, the following procedure:

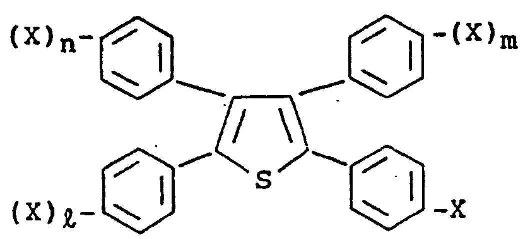
(1) A process of reacting an amino compound represented by the general formula (V)



(V)

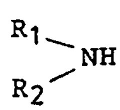
wherein each of ℓ, m and n is an integer of 0 or 1 and is selected to meet the condition formula $\ell \geqq m \geqq n$, with an alkyl paratoluenesulfonate, dialkyl sulfate, an alcohol, an alkyl halide, aryl halide or the like.

(2) Anotehr method of reacting a compound represented by the general formula (VI)



(VI)

wherein each of ℓ, m and n is an integer of 0 or 1 and is selected to meet the condition formula $\ell \geqq m \geqq n$, and X is a halogen atom, preferably a iodine atom, with an amine compound represented by the general formula (VII)

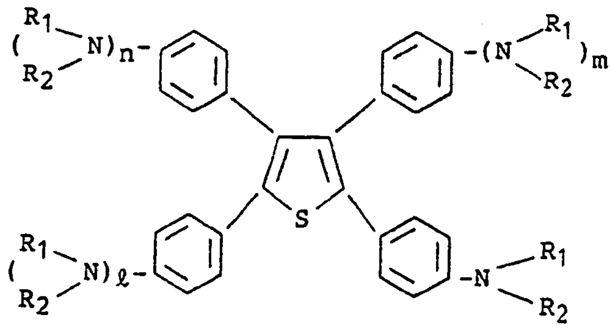


(VII)

wherein R_1 and R_2 are as defined above in the forlumal (I).

Typical examples of compounds which can be used in the present invention are recited in Table 1, but these examples are not restrictive.

Table 1 (I)



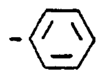
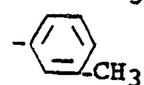
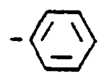
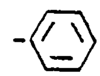
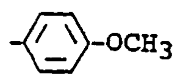
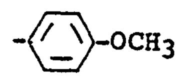
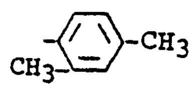
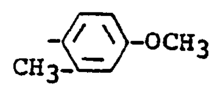
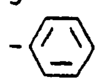
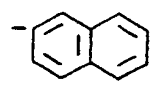
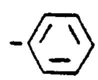
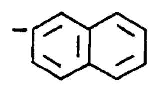
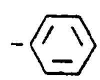
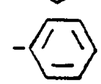
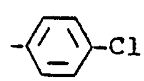
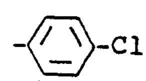
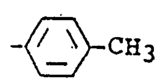
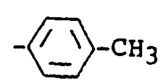
Compound No.	ℓ	m	n	R_1	R_2
1	0	0	0		
2	0	0	0		
3	0	0	0		
4	0	0	0		
5	0	0	0		
6	0	0	0		
7	1	0	0		
8	1	0	0		
9	1	0	0		
10	1	0	0		

Table 1 (II)

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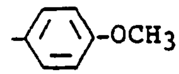
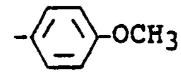
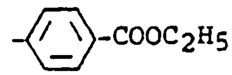
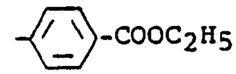
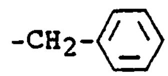
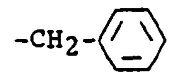
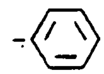
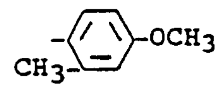
11	1	0	0		
12	1	0	0		
13	1	0	0		
14	1	0	0		
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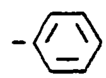
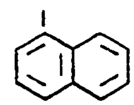
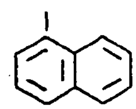
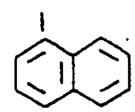
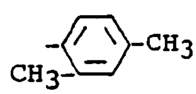
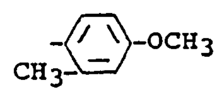
16	1	0	0		
17	1	0	0		
18	1	0	0		
19	1	0	0		
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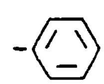
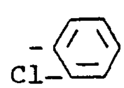
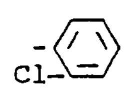
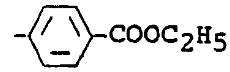
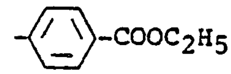
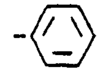
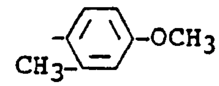
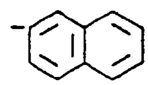
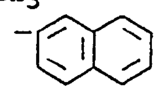
21	1	1	0		
22	1	1	0		

Table 1 (III)

Compound No.	P	m	n	R_1	R_2
23	1	1	0		
24	1	1	0		
25	1	1	0		
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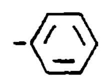
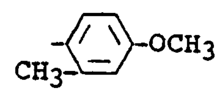
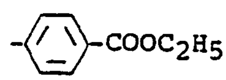
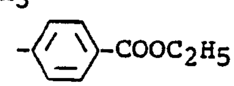
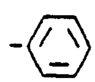
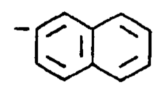
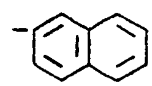
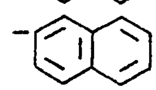
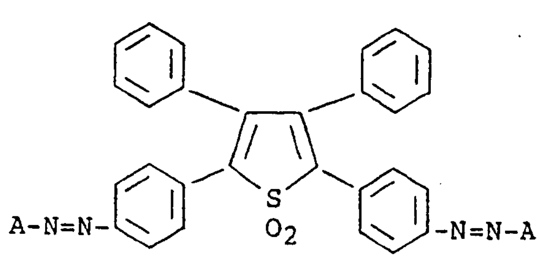
27	1	1	1		
28	1	1	1		
29	1	1	1		
30	1	1	1		
31	1	1	1		

The compound of the present invention which is a charge-transporting material is combined with a charge-generating material to constitute an electrophotographic photoreceptor.

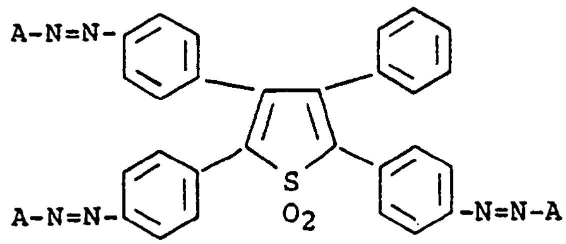
As the charge-generating material, any material can be used so long as it has an ability to generate an electric charge. Typical examples of the charge-generating material include inorganic materials such as selenium, selenium alloys, amorphous silicon and cadmium sulfide; and organic dyes and pigments of phthalocyanine, perylene, perynone, indigo, anthraquinone, cyanine, azo compounds, and the like. Above all, charge-generating materials of the phthalocyanine and azo compounds are suitable for the use in combination with the charge-transporting material of the present invention.

Furthermore, of the azo compound charge-generating materials which can provide the electrophotographic photoreceptor having excellent characteristics in combination with the charge-transporting material of the present invention, the compounds represented by the following formulae (II), (III) and (IV) are particularly preferable:



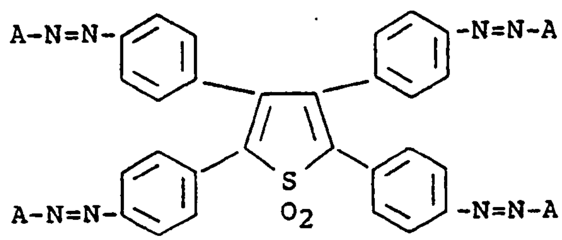
(II)

wherein A is a coupler residuum,



(III)

wherein A is a coupler residuum,



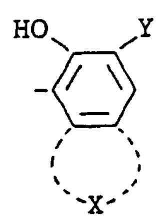
(IV)

wherein A is a coupler residuum.

The reason why it is particularly desirable to use each of these compounds in combination with the charge-transporting material would be based on various factors, but the presumption of these factors is extremely difficult on a present technical level in this field. It should be here noted that the combination of the charge-transporting material of the present invention and the azo compound charge-generating material having the aforesaid structural formula (II), (III) or (IV) is also on the basis of surprising discovery.

Examples of the coupler residuum represented by the group A in the general formulae (II), (III) and (IV) include the following residua (a) to (d):

(a) Coupler residua having the general formula (VIII)



(VIII)

wherein X is a hydrocarbon ring which may be substituted, or a heterocyclic ring which may be substituted; and Y is -CON(R_4)-R_3 or -CONH•N=C(R_6)-R_5 wherein R_3 is a hydrocarbon ring group which may be substituted, or a heterocyclic ring group which may be substituted, R_4 is hydrogen, an alkyl group which may be substituted, or a phenyl group which may be substituted, R_5 is a hydrocarbon ring group which may be substituted, a heterocyclic ring group which may be substituted, or a styryl group which may be substituted, R_6 is hydrogen, an alkyl group which may be substituted, or a phenyl group which may be substituted, and R_5 and R_6 may form a ring together with carbon atoms which link therewith.

Typical examples of X in the general formula (VIII) include hydrocarbon rings such as a naphthalene ring and an anthracene ring, and heterocyclic rings such as an indole ring, a carbazole ring, a benzocarbazole ring and a dibenzofuran ring, which are each condensed with the benzene ring having a hydroxyl group and Y.

In case that X has a substituent, examples of this substituent include halogen atoms such as a chlorine atom and a bromine atom as well as a hydroxyl group.

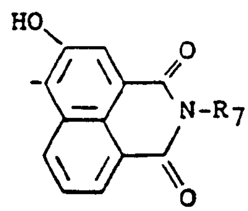
Examples of the cyclic group of R_3 or R_5 include hydrocarbon ring groups such as a phenyl group, a naphtyl group, an anthryl group and a pyrenyl group; and heterocyclic ring groups such as a pyridyl group, a thienyl group, a furyl group, an indolyl group, a benzofuranyl group, a carbazolyl group and a

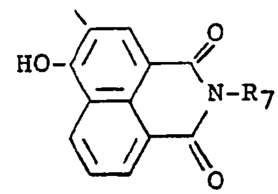
dibenzofuranyl group. Moreover, another example of the ring which can be formed by the linkage of R_5 with R_6 is a fluorene ring.

In case that R_3 or R_5 has a substituent, examples of this substituent include alkyl groups such as a methyl group, an ethyl group, a propyl group and a butyl group, alkoxy groups such as a methoxy group, an ethoxy group, a propoxy group and a butoxy group, halogen atoms such as a chlorine atom and a bromine atom, a halomethyl group such as trifluoromethyl group, dialkylamino groups such as a dimethylamino group and a diethylamino group, a nitro group, a cyano group, a carboxyl group and esters thereof.

When R_4 or R_6 is the phenyl group, an example of its substituent is a halogen atom such as a chlorine atom or a bromine atom.

(b) Coupler residua having general formulae (IX) and (X)

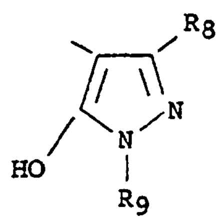

(IX)


(X)

wherein R_7 is a hydrocarbon group which may be substituted.

Typical examples of R_7 include alkyl groups such as a methyl group, an ethyl group, a propyl group, a butyl group and an octyl group, and alkoxyalkyl groups such as a methoxyethyl group and an ethoxyethyl group.

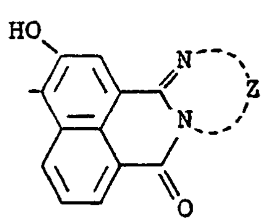
(c) Coupler residues having general formula (XI)

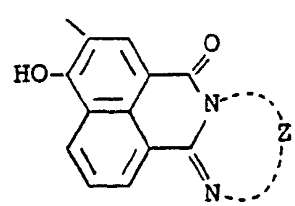

(XI)

wherein R_8 is an alkyl group, a cabamoyl group, a carboxy group or its ester, and R_9 is a hydrocarbon ring group which may be substituted.

Typical examples of R_9 include hydrocarbon ring groups such as a phenyl group and a naphthyl group. In case that the group of R_9 has a substituent, examples of this substituent include alkyl groups such as a methyl group, an ethyl group, a propyl group and a buty group, alkoxy groups such as a methoxy group, an ethoxy group, a propoxy group and a butoxy group, dialkylamino groups such as a dimethylamino group and a diethylamino group, halogen atoms such as a chlorine atom and a bromine atom, a nitro group and a cyano group.

(d) Coupler residues having general formula (XII) and (XIII)


(XII)


(XIII)

wherein Z is a divalent hydrocarbon ring group which may be substituted, or a divalent heterocyclic ring group which may be substituted.

Typical examples of Z include a divalent monocyclic aromatic hydrocarbon group such as an o-phenylene group, condensed polycyclic aromatic hydrocarbon groups such as an o-naphthylene group, a peri-naphthylene group, a 1,2-anthraquinonylene group and a 9,10-phenanthrylene group, and divalent heterocyclic ring groups such as a 3,4-pyrazoldiyl group, a 2,3-pyridinediyl group, a 4,5-pyrimidinediyl group, a 6,7-imidazolediyl group, a 5,6-benzimidazolediyl group and a 6,7-quinolinediyl group. When the ring group of Z has a substituent, examples of this substituent include alkyl groups such as a methyl group, an ethyl group, a propyl group and a butyl group, alkoxy groups such as a methoxy group, an ethoxy group, a propoxy group and a butoxy group, dialkylamino groups such as a dimethylamino group and a diethylamino group, halogen atoms such as a chlorine atom and a bromine atom, a nitro group and a cyano group.

Of the coupler residua above recited, those which are represented by the general formula (VIII) are most preferable and they have high photosensitve properties and their intermediate raw materials are so easily available that they can be manufactured at low cost.

Typical examples of the coupler residues are as follows:

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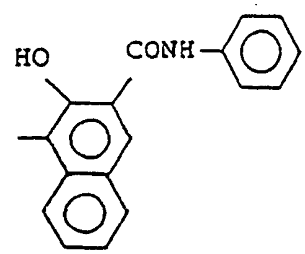

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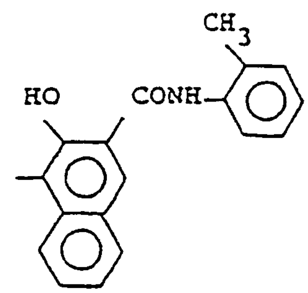

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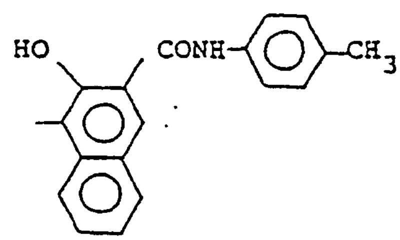

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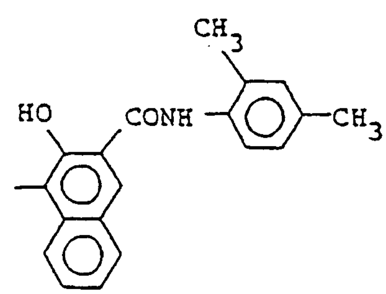

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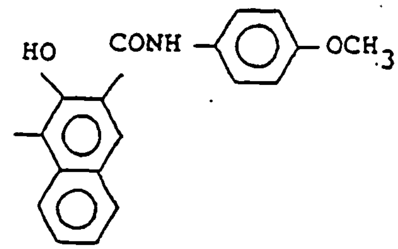

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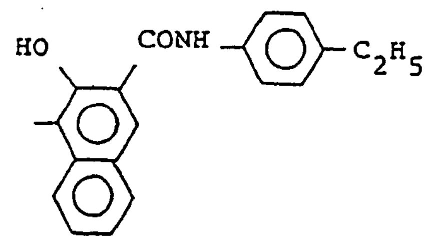

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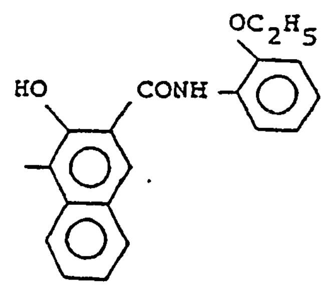

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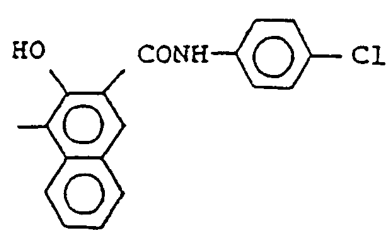

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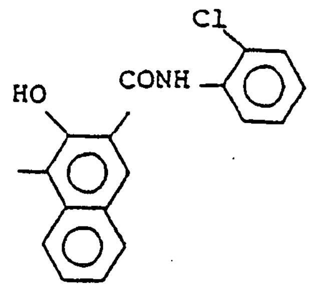

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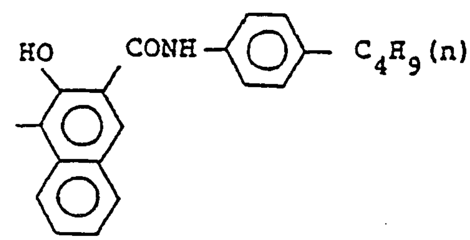

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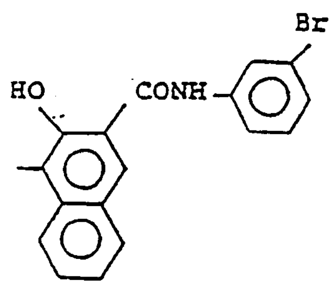

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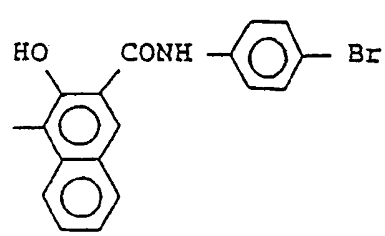

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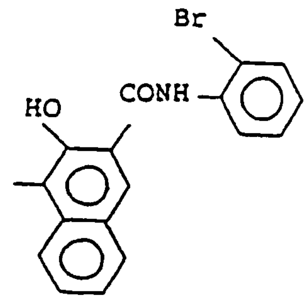

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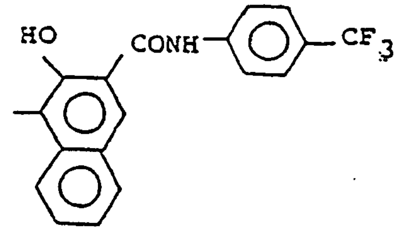

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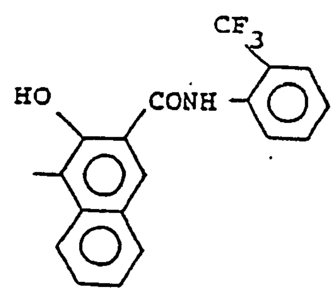

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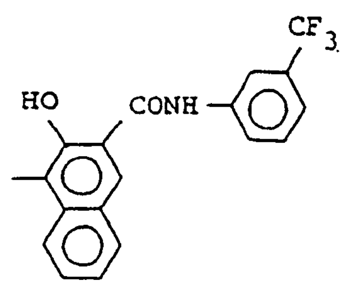

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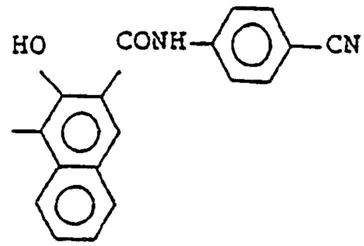

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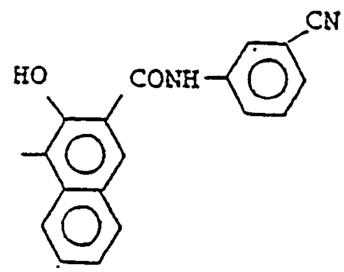

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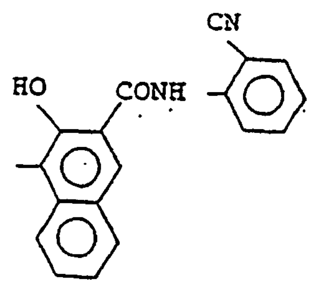

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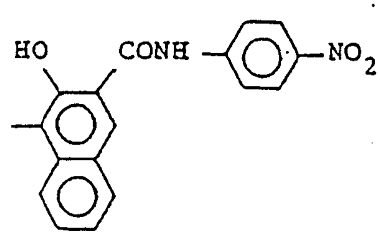

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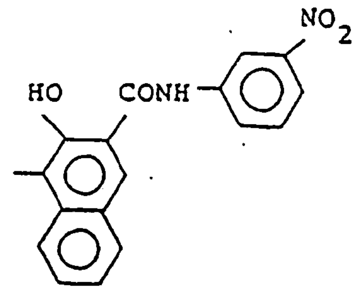

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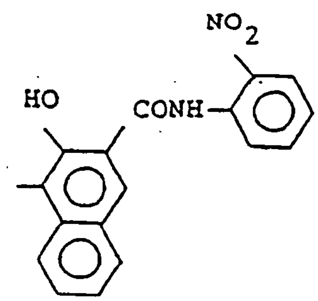

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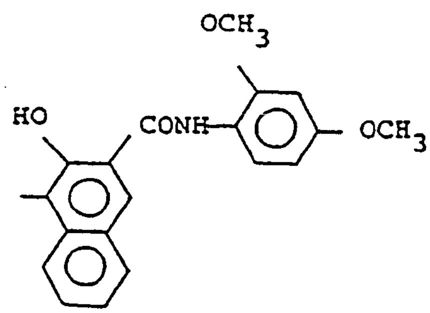

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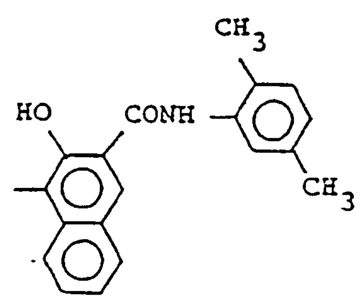

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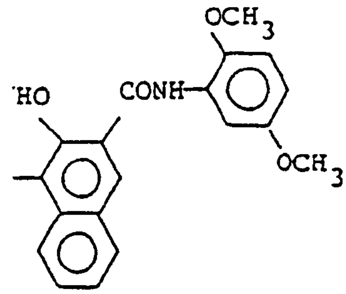

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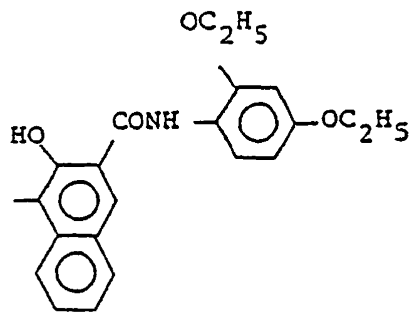

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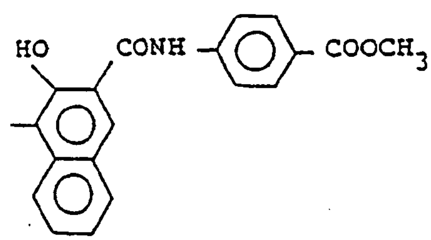

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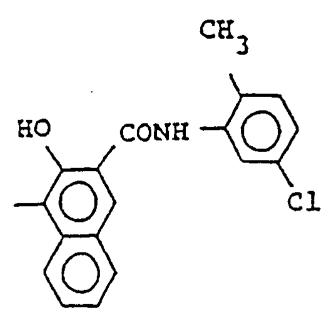

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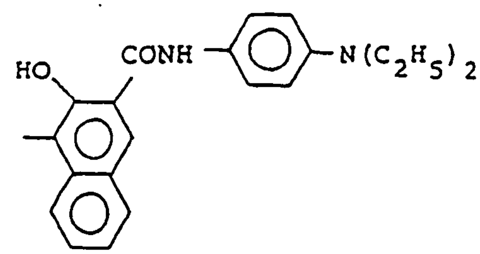

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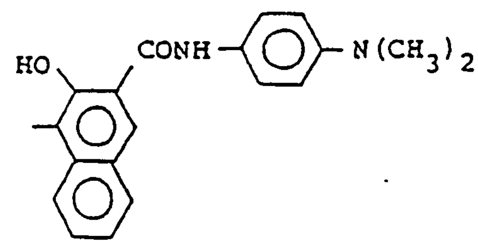

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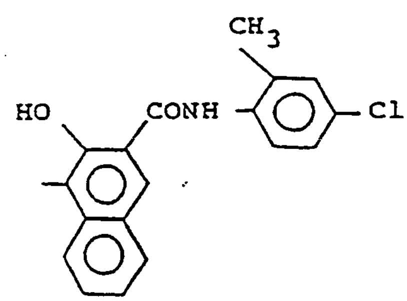

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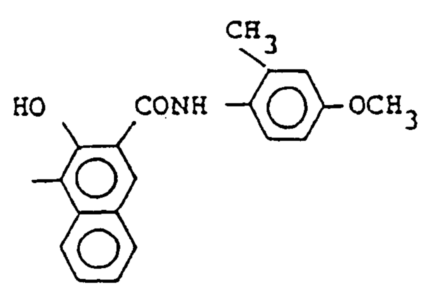

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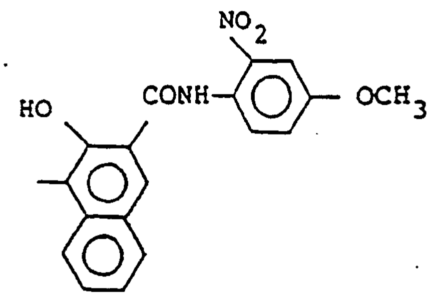

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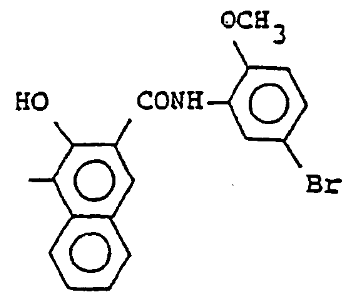

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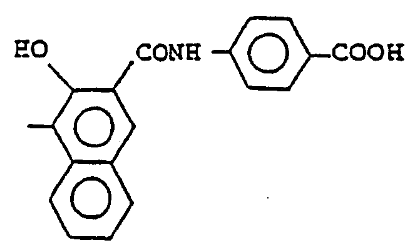

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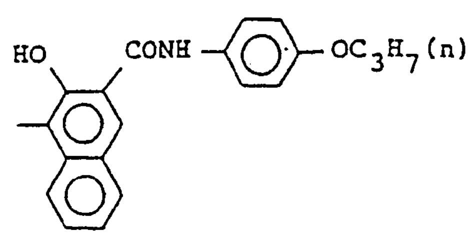

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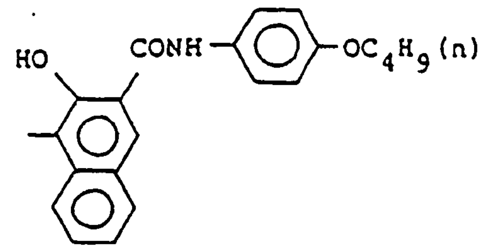

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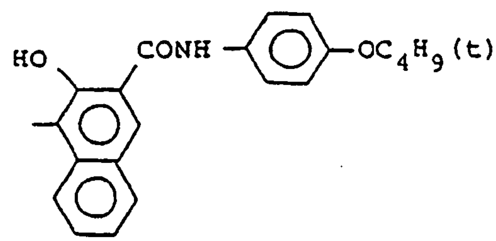

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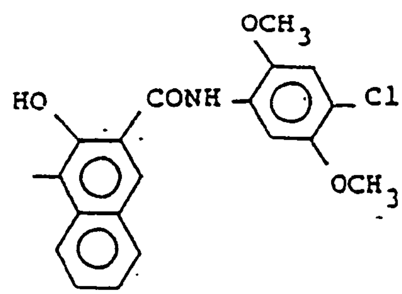

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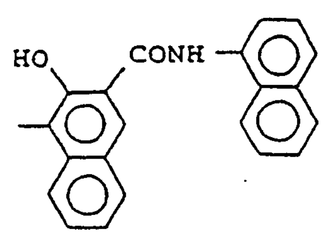

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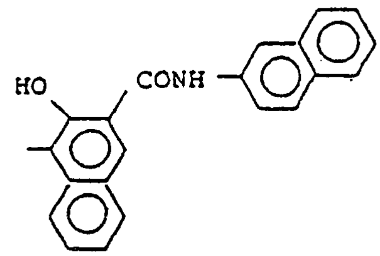

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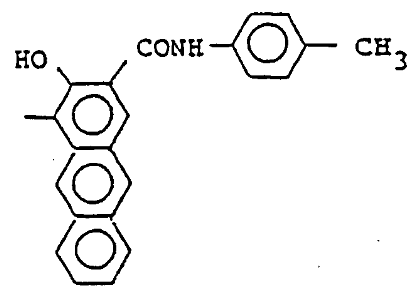

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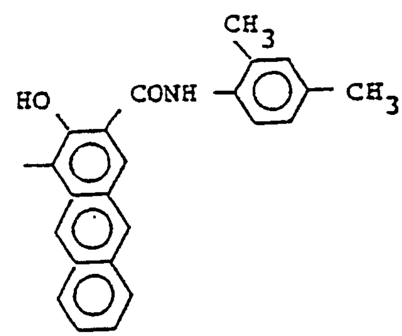

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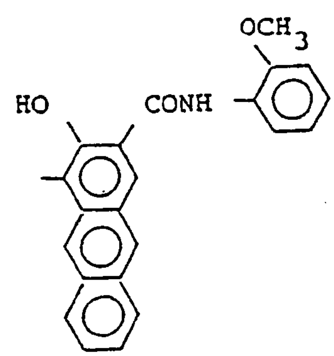

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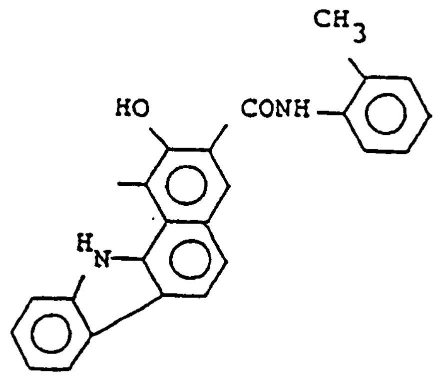

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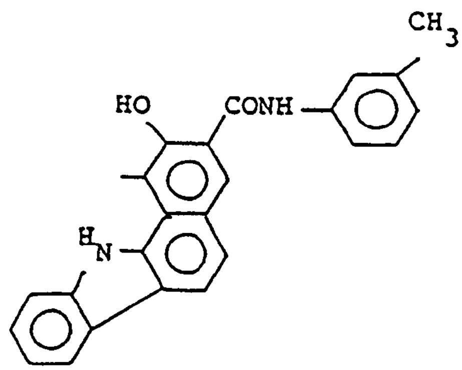

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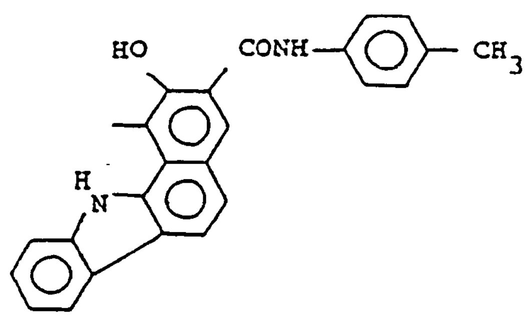

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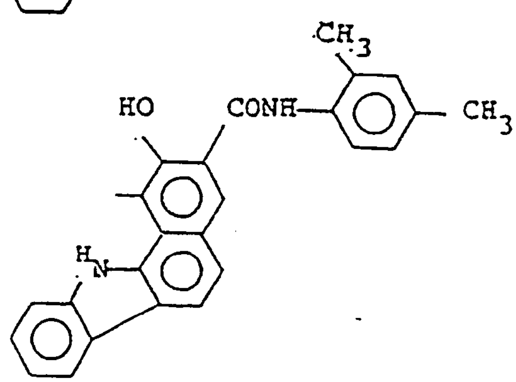

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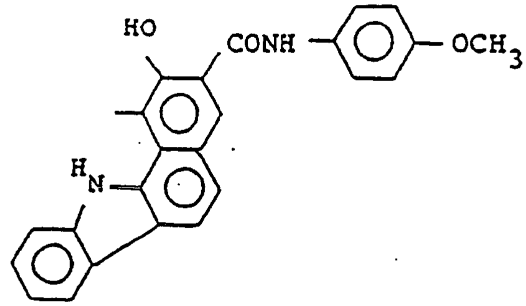

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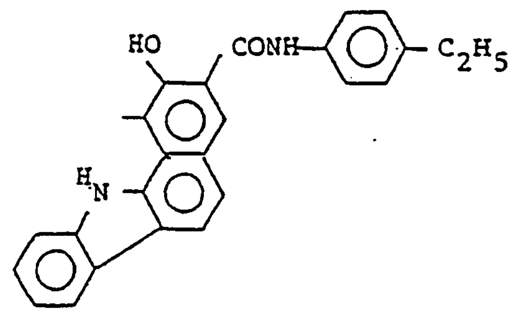

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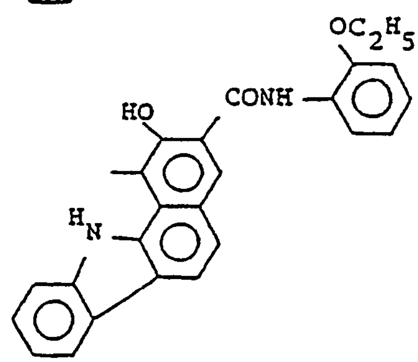

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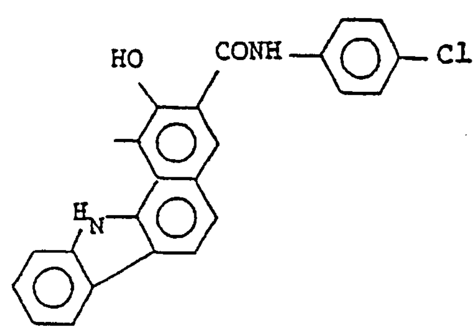

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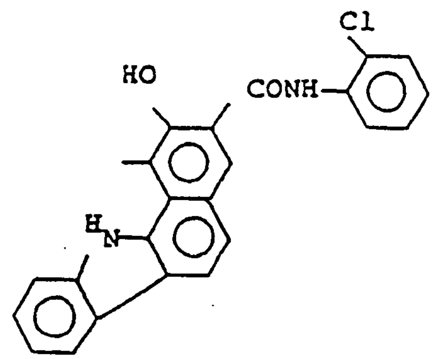

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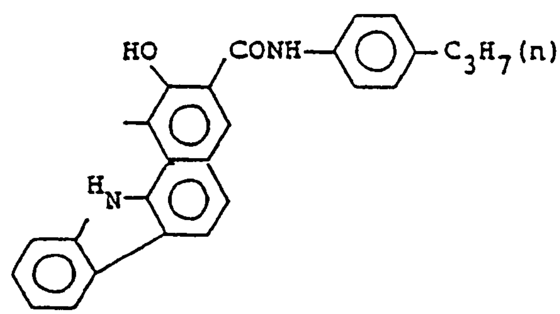

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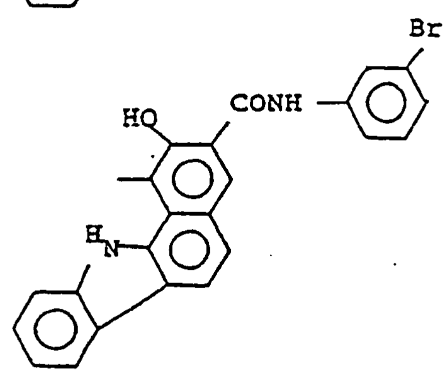

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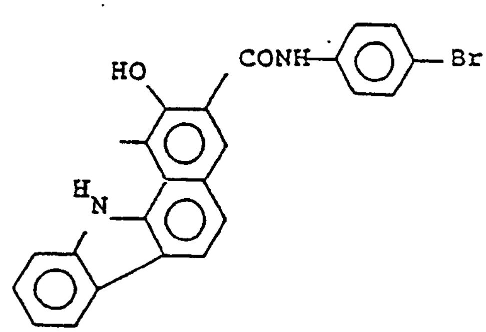

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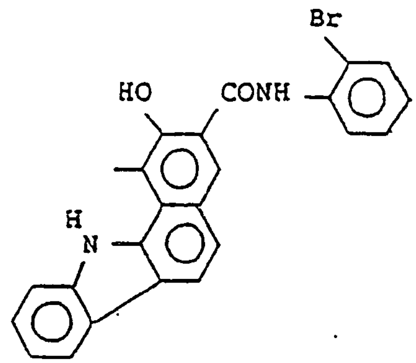

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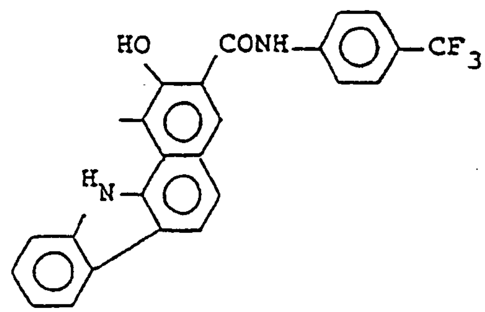

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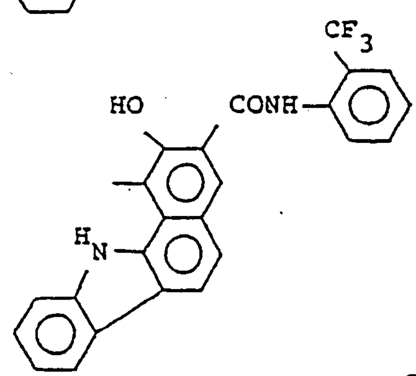

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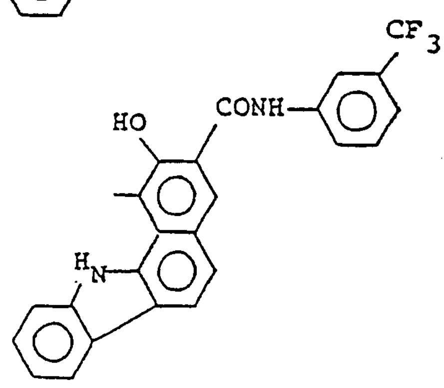

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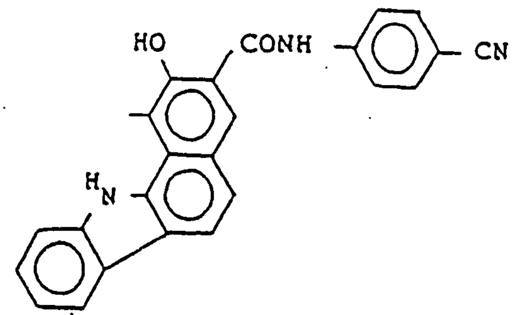

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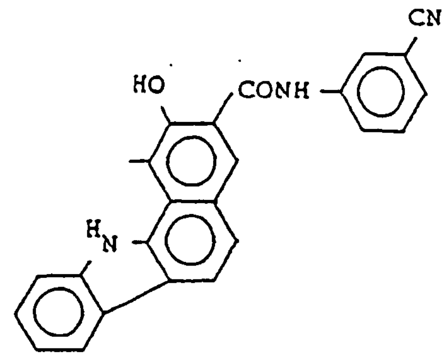

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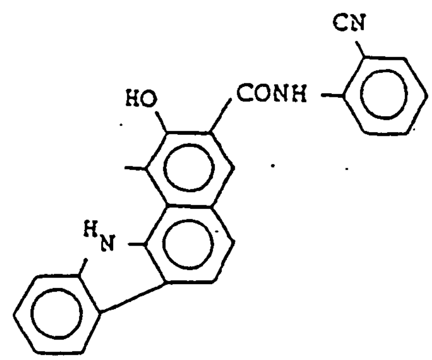

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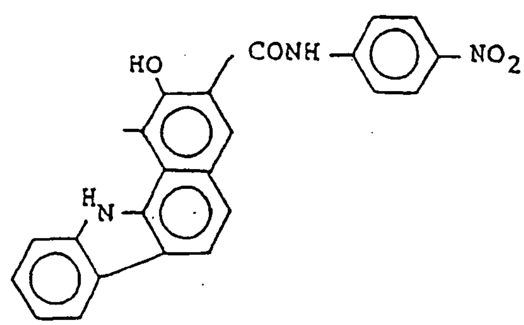

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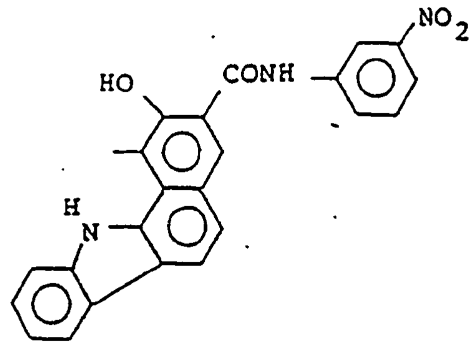

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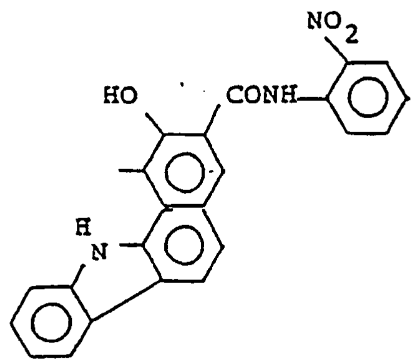

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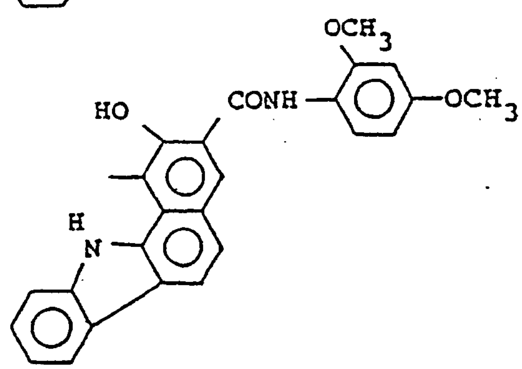

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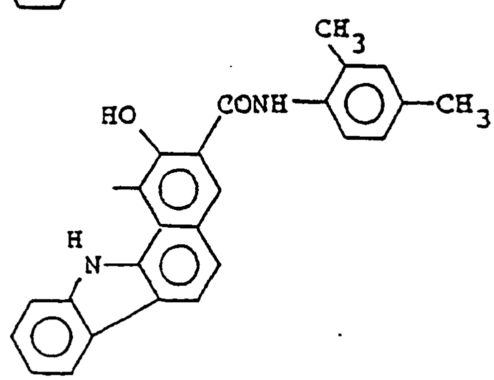

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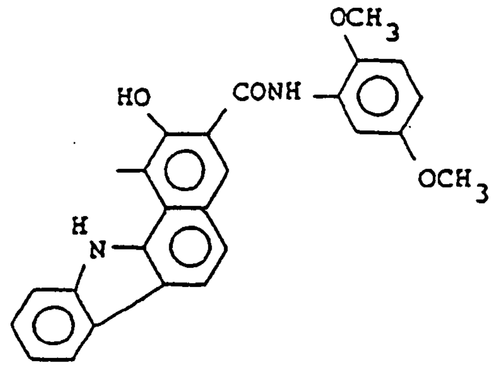

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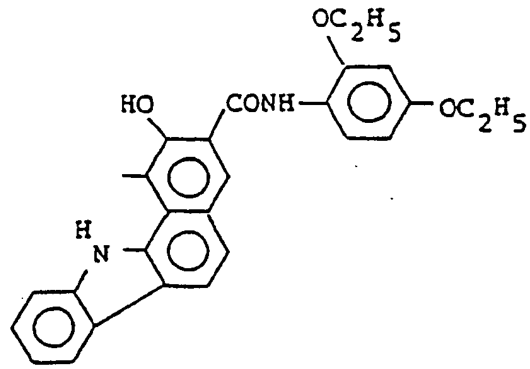

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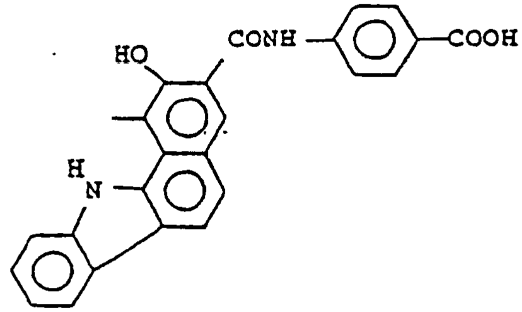

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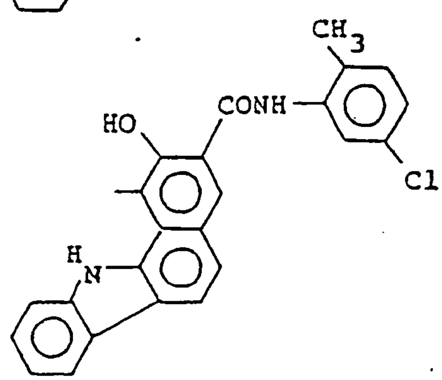

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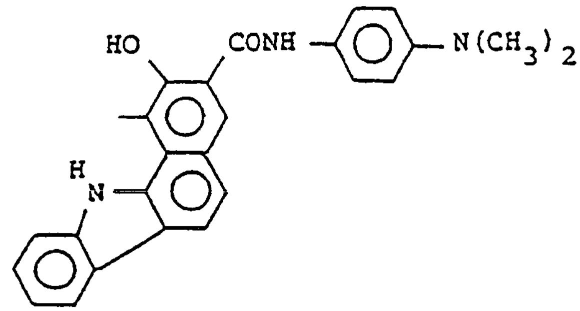

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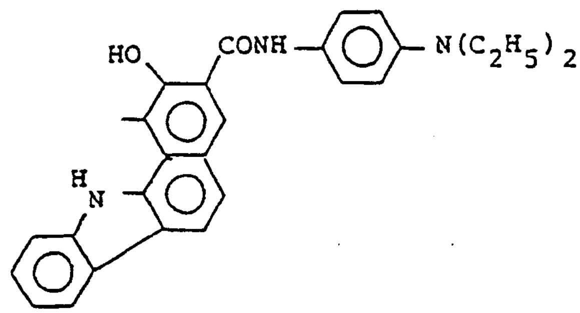

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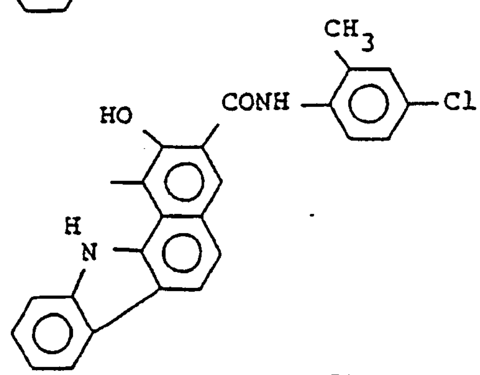

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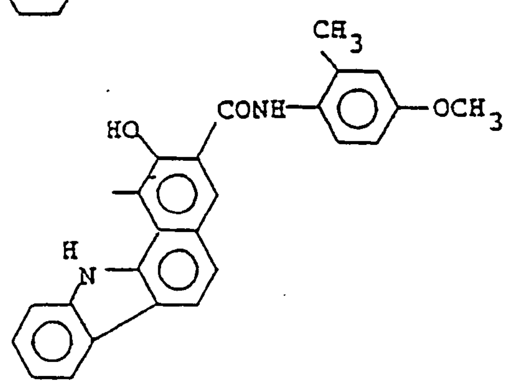

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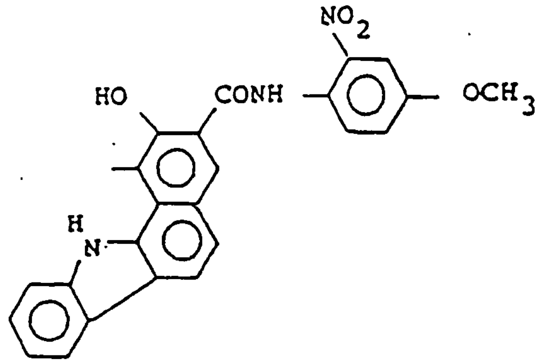

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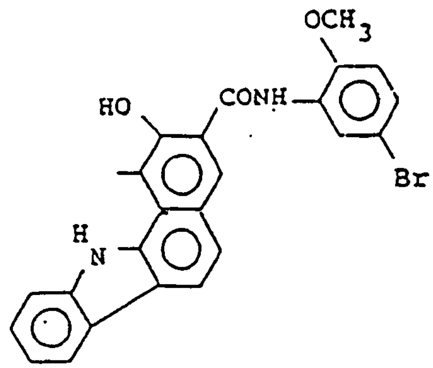

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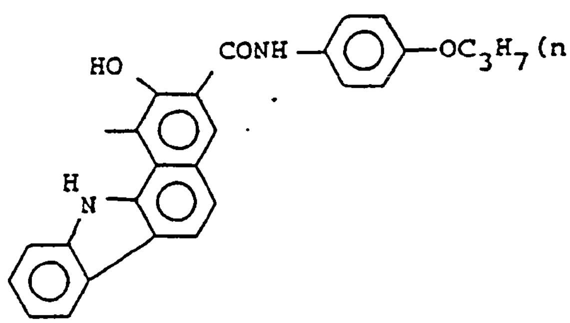

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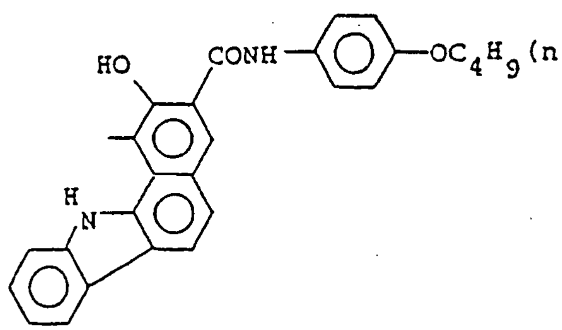

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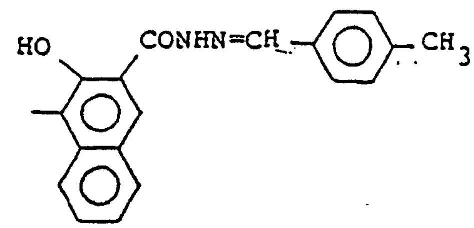

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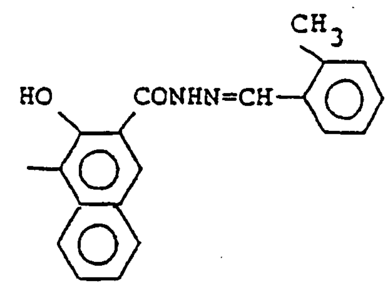

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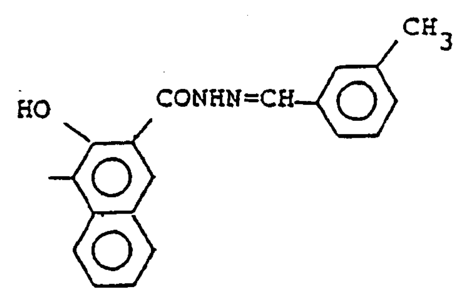

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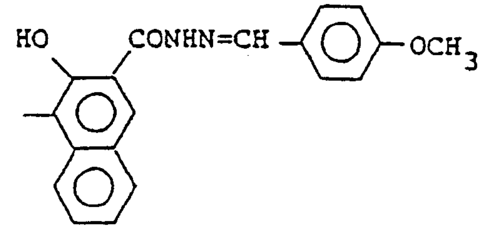

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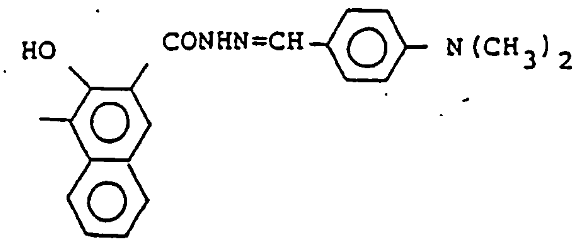

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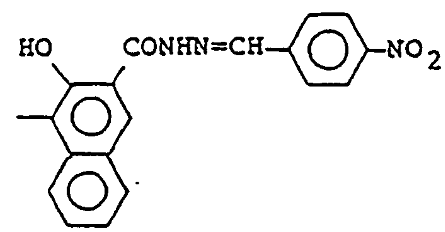

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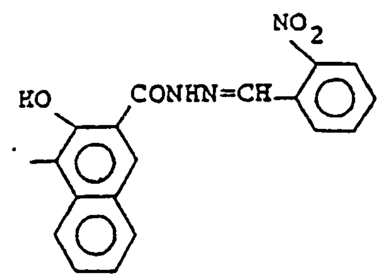

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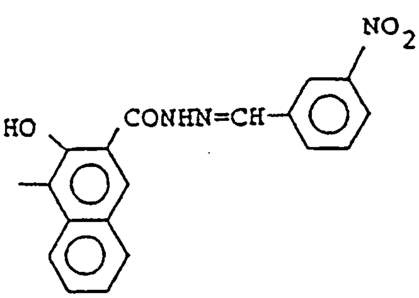

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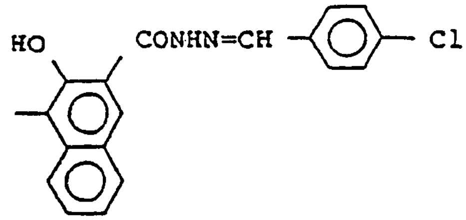

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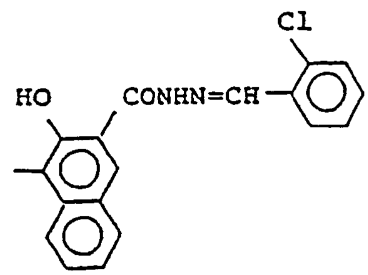

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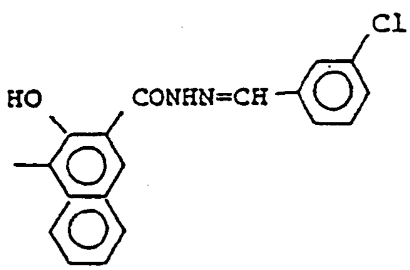

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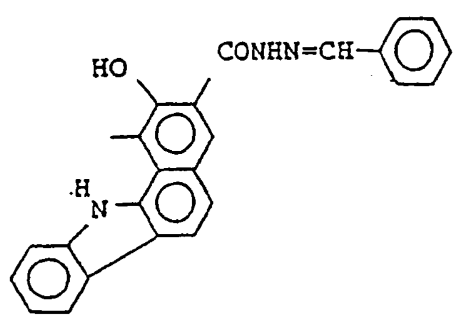

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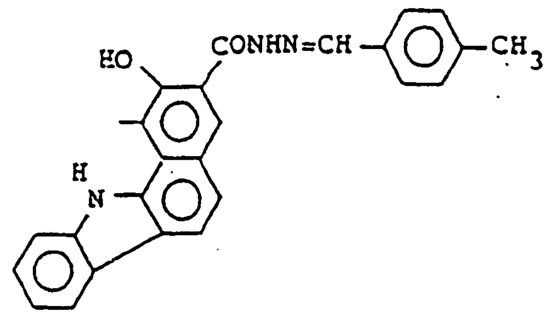

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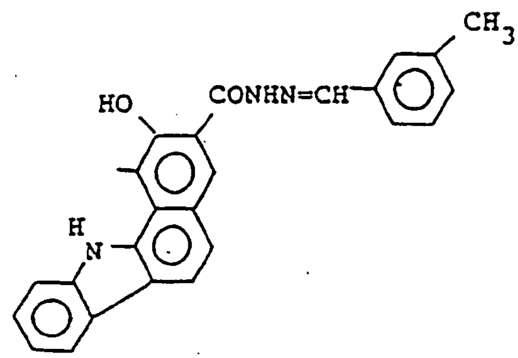

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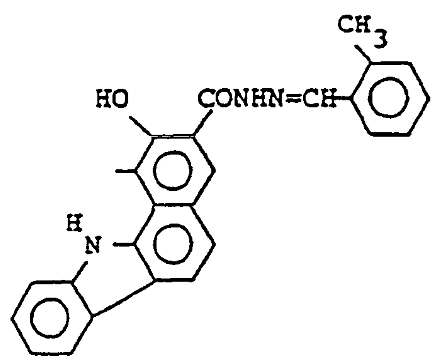

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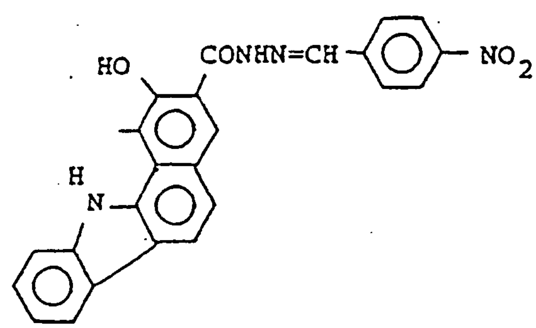

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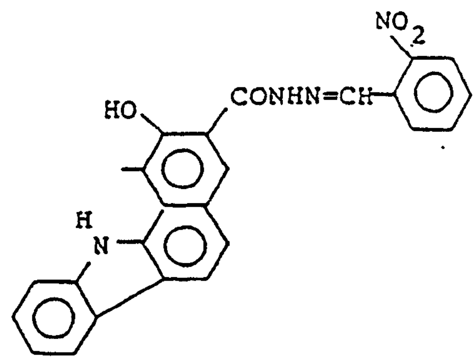

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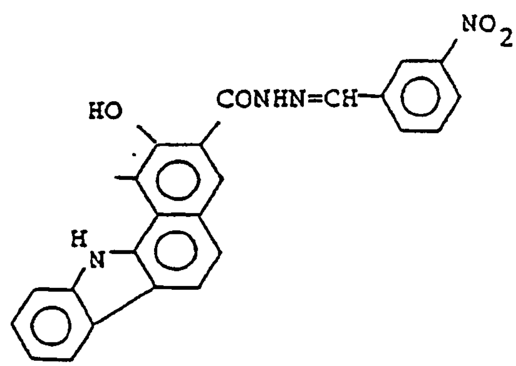

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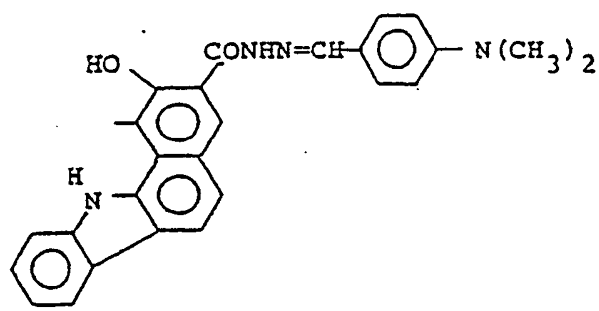

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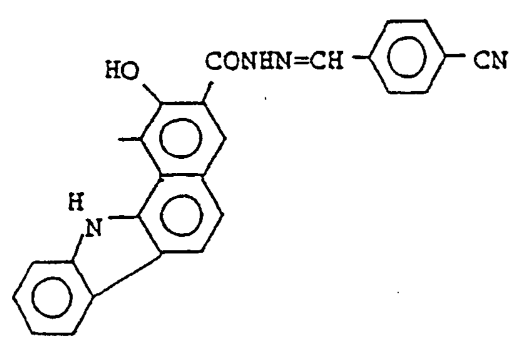

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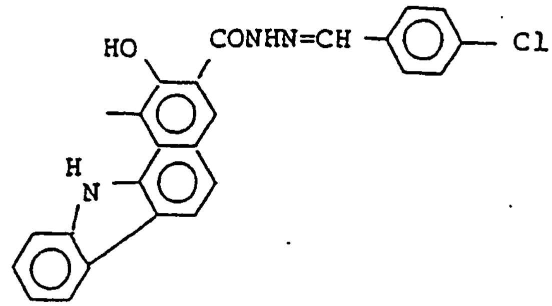

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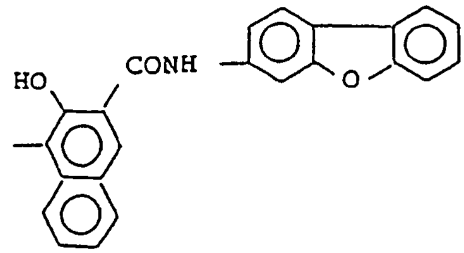

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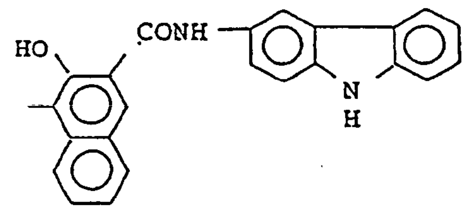

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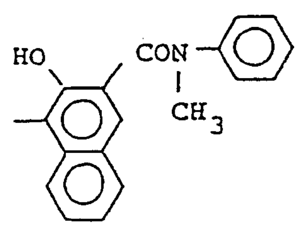

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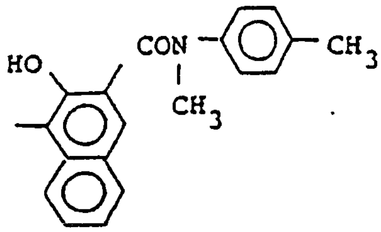

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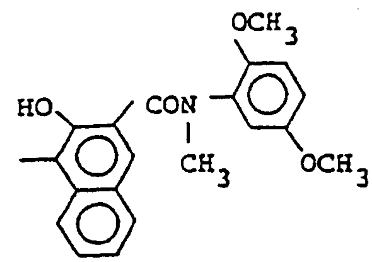

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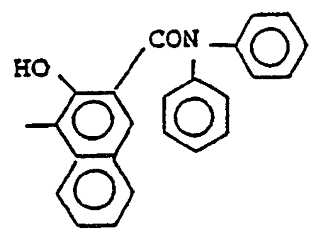

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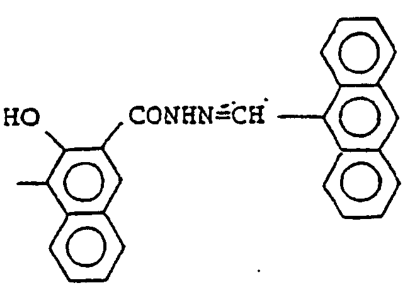

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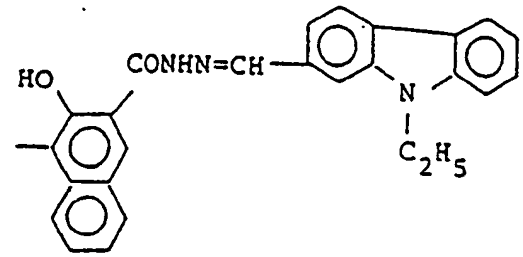

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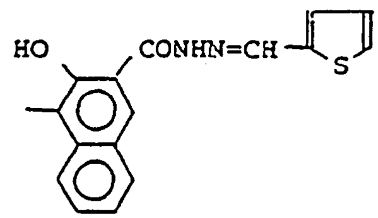

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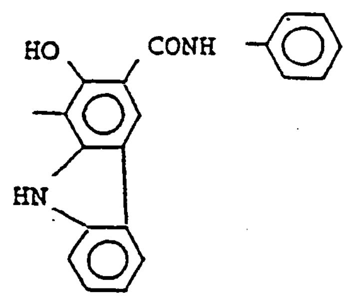

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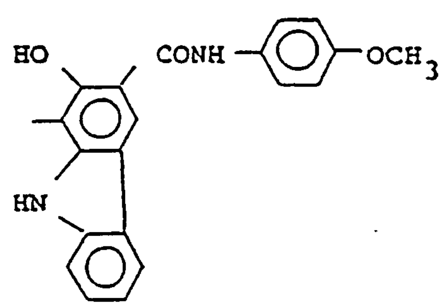

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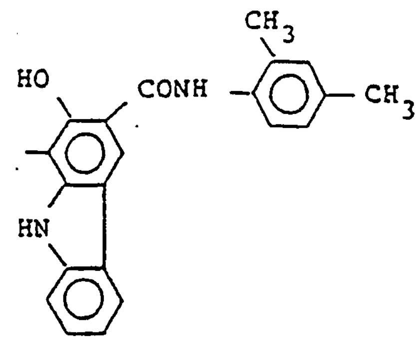

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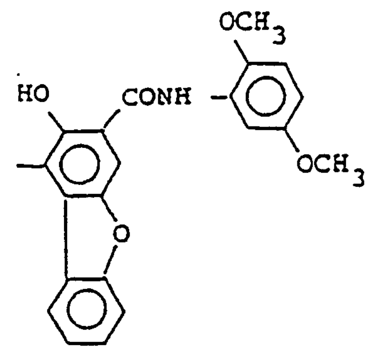

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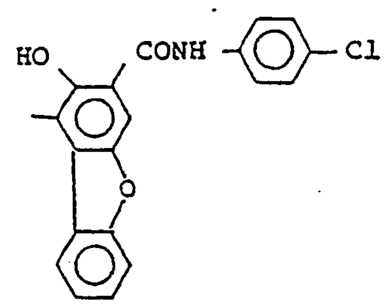

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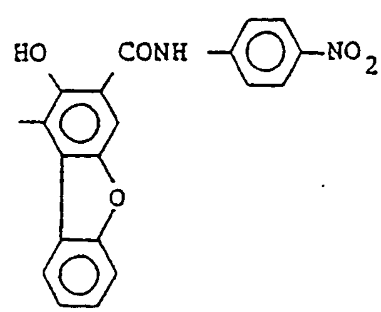

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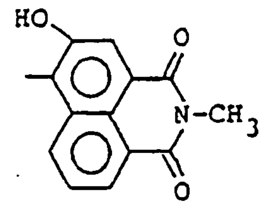

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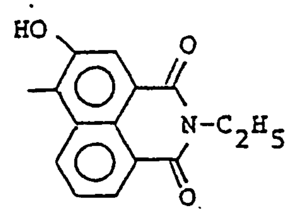

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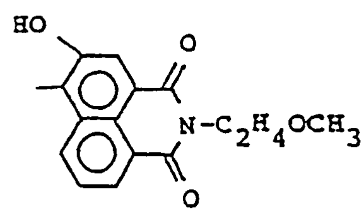

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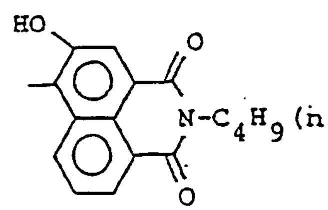

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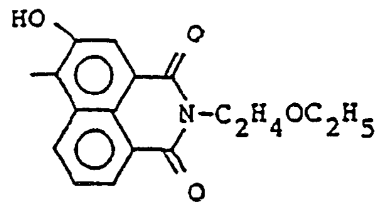

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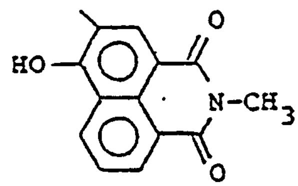

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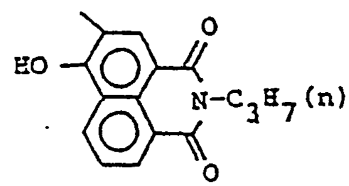

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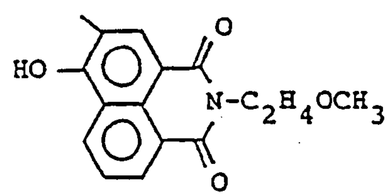

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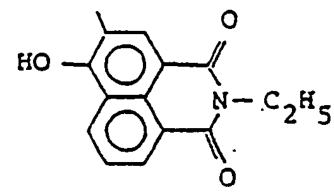

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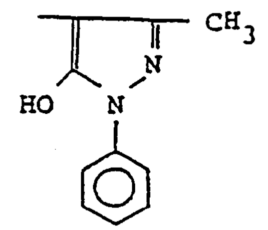

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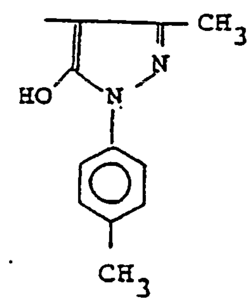

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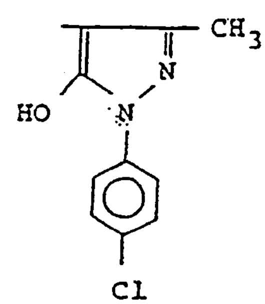

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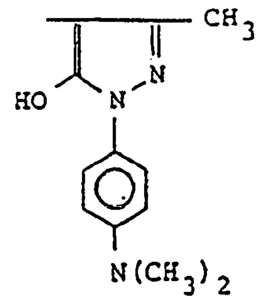

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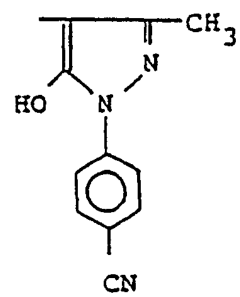

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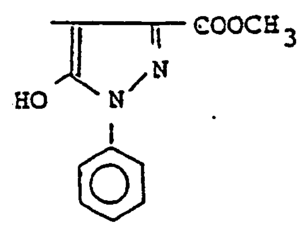

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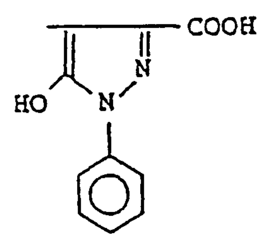

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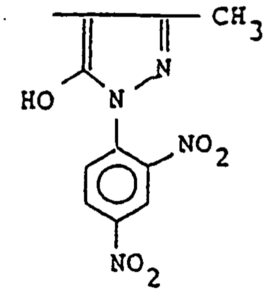

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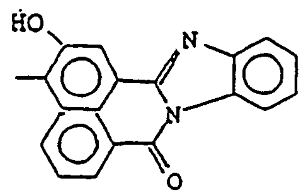

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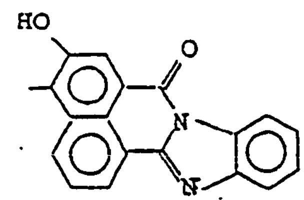

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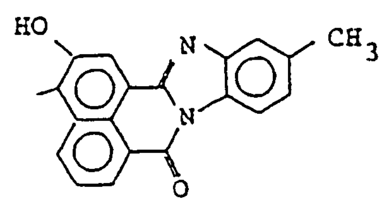

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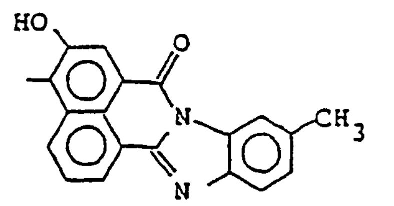

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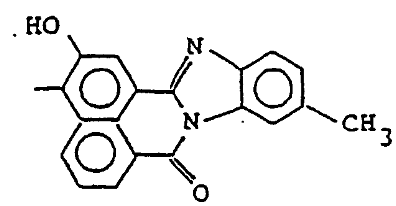

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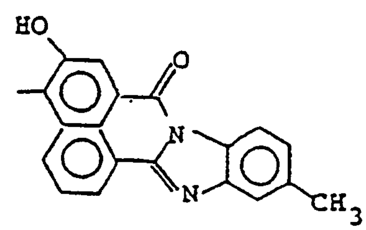

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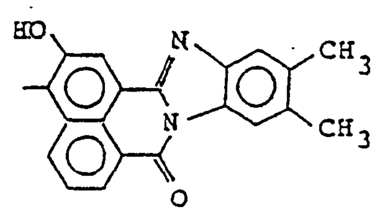

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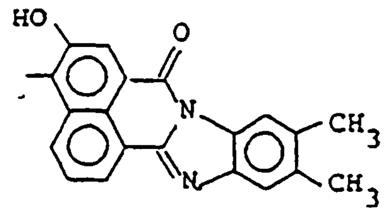

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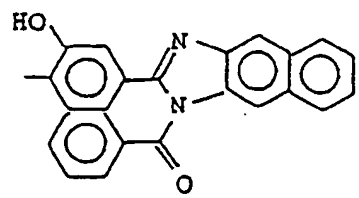

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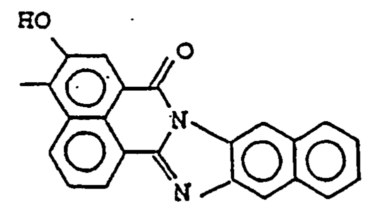

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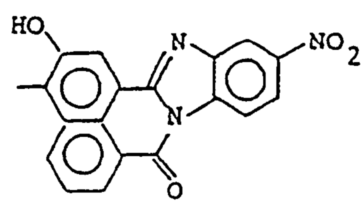

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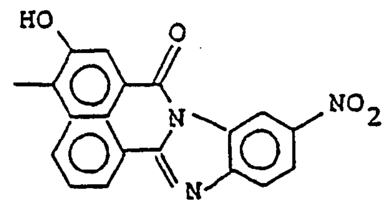

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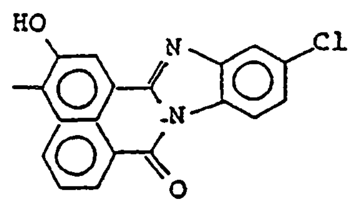

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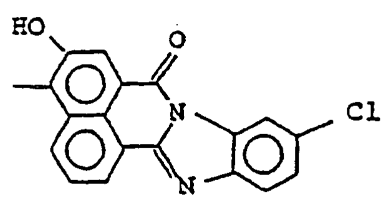

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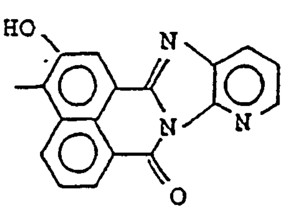

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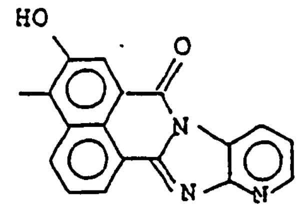

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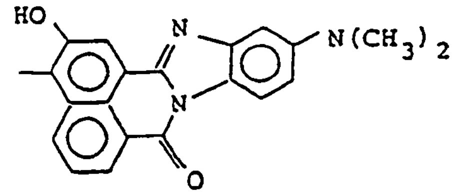

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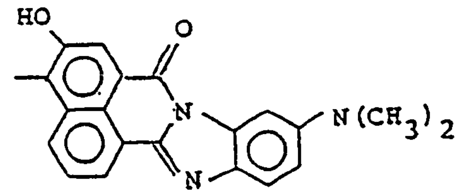

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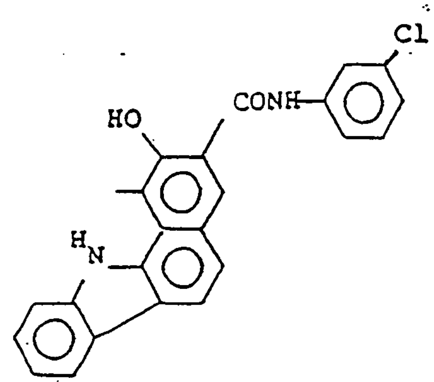

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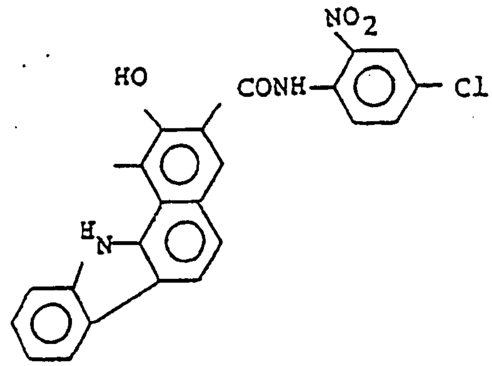

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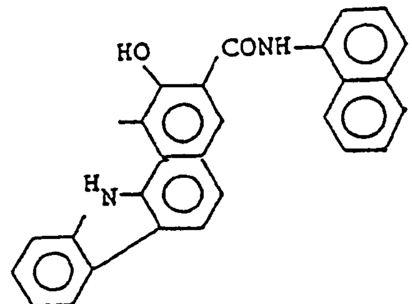

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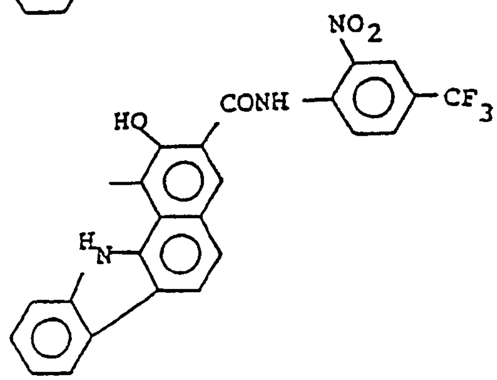


The azo compounds represented by the general formula (II), (III) and (IV) can be manufactured by, for example, a method disclosed in EP 0270685.

The compound of the present invention has no ability to provide coating films by itself, and therefore it is used together with a binder in order to form a photosensitive layer. As the binder, an insulating polymer can be employed. Examples of the insulating polymer include polystyrene, polyacrylamide, polyvinyl chloride, polyester resins, polycarbonate resins, epoxy resins, phenoxy resins and polyamide resins. In particular, the polyester resins and polycarbonate resins can be suitably used. In addition, poly-N-vinylcarbazole which has charge-transporting ability by itself can be also employed.

The photoreceptor may be in the form of a constitution in which a photosensitive layer 4 containing a charge-generating material 2 and a charge-transporting material 3 is superposed upon an electrically conductive base 1, as shown in Fig. 1; a constitution in which a photosensitive layer 4′ is superposed upon the electrically conductive base 1, the photosensitive layer 4′ being composed of a charge-generating layer 6 containing the charge-generating material 2 and a charge-transporting layer 5 containing the charge-transporting material 3 thereon, as shown in Fig. 2; and a constitution in which the charge-generating layer 6 and the charge-transporting layer 5 in Fig. 2 are inversely disposed. The photoreceptor having any one of the above-mentioned constitutions is effective in the present invention, but the laminate type photoreceptor shown in Fig. 2 is preferble in that excellent electrophotographic characteristics can be obtained.

The constitution of the photoreceptor will be further described in detail in reference to Fig. 2.

Examples of usable raw materials for the electrically conductive base 1 include metallic plates of aluminum, copper and zinc; those which have been prepared by depositing conductive materials such as aluminum and SnO_2 on plastic sheets or films of polyester and the like; and papers or resins which have been rendered conductive.

The charge-generating layer 6 can be formed from the above-mentioned charge-generating material 2 in accordance with a method of vacuum-evaporating the charge-generating material 2 on the electrically conductive base 1, a method of applying and drying a solution containing the charge-generating material 2, a method of applying and drying a dispersion in which fine particles of the charge-generating material 2 are dispersed, or another method.

The thickness of the charge-generating layer 6 is in the range of 0.01 to 5 µm, preferably 0.05 to 2 µm. When this thickness is less than 0.01 µm, the generation of the charge is insufficient, and when it is more than 5 µm, residual potential is high, which is practically unpreferable.

The charge-transporting layer 5 may be formed by dissolving the compound of the present invention and the above-mentioned binder in a suitable solvent, and then applying and drying the mixture. In the charge-transporting layer 5, the charge-transporting material 3 is contained in an amount of 10 to 95% by weight, preferably 30 to 90% by weight. When the charge-transporting material 3 is less than 10% by weight, the charge is scarcely transported, and when it is more than 95% by weight, mechanical strength of the photoreceptor is poor, which is practically unpreferable.

The thickness of the charge-transporting layer 5 is preferably in the range of 3 to 50 µm, more preferably 5 to 30 µm. When this thickness is less than 3 µm, electrification quantity is insufficient, and when it is more than 50 µm, residual potential is high, which is practically unpreferable.

Between the photosensitive layer and the electrically conductive base, an intermediate layer may be interposed. Suitable examples of raw materials for the intermediate layer include polyamide, nitrocellulose, casein and polyvinyl alcohol, and the thickness of the intermediate layer is preferably 1 µm or less.

As described above, the electrophotographic photoreceptor of the present invention may be composed of the compound represented by the general formula (I), the electrically conductive base, the charge-generating material and the binder, but other constitutional elements of the photoreceptor may be additionally used, so long as they have functions as such elements.

In the electrophotographic photoreceptor of the present invention, a novel compound represented by the general formula (I) is used as the charge-transporting material, and therefore this photoreceptor has high sensitivity, sufficient durability to repeating use, and other excellent advantages.

Now, the present invention will be described in detail by way of examples, but the scope of the present invention should not be limited to these examples.

Preparation Example 1

(Synthesis of Exemplary Compound No. 7)

In 50 ml of sulfolane were dispersed 12 g of 2,5-bis(4-iodophenyl)-3,4-diphenylthiophene, 10 g of N-phenyl-2-naphthylamine, 10 g of anhydrous potassium carbonate and 8 g of electrolytic copper, and the mixture was then stirred at 190 °C for 40 hours. After standing, the mixture was added to 100 ml of water, and the resultant precipitate was collected by filtration and was then washed with water and methanol in this order, followed by drying. The thus obtained crude product was extracted with benzene, and the extract was purified through a silica gel column chromatograph using a mixed solvent of benzene and hexane (1:1) as a developing solution. By recrystallization from a mixed solvent of benzene and acetonitrile, 15 g of light-yellow crystals (melting point = 145 to 146 °C) was obtained.

It was confirmed by elemental analysis that the product was Exemplary Compound No. 7.

Results of Elemental Analysis (%)				
	C	H	N	S
Calcd.	87.56	5.14	3.40	3.90
Found	87.34	5.08	3.31	4.04

Preparation Example 2

(Synthesis of Exemplary Compound No. 3)

In 200 ml of orthodichlorobenzene (hereinafter referred to simply as ODCB) was dissolved 4.1 g of 2-(4-aminophenyl)-3,4,5-triphenylthiophene, and to the mixture were added 5.1 g of iodobenzene, 11 g of anhydrous potassium carbonate, 2.6 g of electrolytic copper and 0.6 g of 18-crown-6-ether. In a nitrogen atmosphere, the mixture was then heated under reflux with vigorous stirring for 48 hours. A solid was collected by filtration, and afterward ODCB was distilled off from the reaction solution by means of steam distillation. The thus obtained residue was purified through a silica gel column chromatograph using benzene as a developing solution. Afterward, by recrystallization from a mixed solvent of benzene and hexane (1:1), 2.5 g of light-yellow crystals (melting point = 225.0 to 228.8° C) was obtained.

It was confirmed by elemental analysis that the product was Exemplary Compound No. 3.

Results of Elemental Analysis (%)				
	C	H	N	S
Calcd.	86.45	5.26	2.52	5.77
Found	86.15	5.00	2.80	6.05

Preparation Example 3

(Synthesis of Exemplary Compound No. 4)

The same procedure as in Preparation Example 2 was conducted with the exception that 4.1 g of 2-(4-aminophenyl)-3,4,5-triphenylthiophene and 8.2 g of p-iodoanisole were used, to obtain 3 g of yellow crystals (melting point = 132.8 to 134.6° C).

It was then confirmed by elemental analysis that the product was Exemplary Compound No. 4.

Results of Elemental Analysis (%)				
	C	H	N	S
Calcd.	81.92	5.40	2.27	5.20
Found	81.90	5.19	2.16	4.91

Preparation Example 4

(Synthesis of Exemplary Compound No. 8)

The same procedure as in Preparation Example 2 was conducted with the exception that 4.2 g of 2,5-bis(4-aminophenyl)-3,4-diphenylthiophene and 12.5 g of iodobenzene were used, to obtain 4 g of light-yellow crystals [melting point = 126 to 129° C; λmax = 370 nm ($CHCl_3$)].

It was then confirmed by elemental analysis that the product was Exemplary Compound No. 8.

Results of Elemental Analysis (%)				
	C	H	N	S
Calcd. Found	86.39 86.29	5.30 4.94	3.88 3.85	4.43 4.18

Preparation Example 5

(Synthesis of Exemplary Compound No. 10)

The same procedure as in Preparation Example 2 was conducted with the exception that 4.2 g of 2,5-bis(4-aminophenyl)-3,4-diphenylthiophene and 13.2 g of p-iodotoluene were used, to obtain 4 g of yellow crystals (melting point = 241.4 to 243.3° C).

It was then confirmed by elemental analysis that the product was Exemplary Compound No. 10.

Results of Elemental Analysis (%)				
	C	H	N	S
Calcd. Found	86.34 86.30	5.95 5.93	3.60 3.52	4.12 4.10

Preparation Example 6

(Synthesis of Exemplary Compound No. 21)

The same procedure as in Preparation Example 2 was conducted with the exception that 4.3 g of 2,3,5-tris(4-aminophenyl)-4-phenylthiophene and 18.5 g of iodobenzene were used, to obtain 4 g of yellow crystals [melting point = 238 to 242° C; λmax = 373 nm ($CHCl_3$)].

It was then confirmed by elemental analysis and from a molecular ion peak at 889(M+) in FD-MASS that the product was Exemplary Compound No. 21.

Results of Elemental Analysis (%)				
	C	H	N	S
Calcd. Found	86.36 86.82	5.32 5.22	4.72 4.52	3.60 3.38

Preparation Example 7

(Synthesis of Exemplary Compound No. 27)

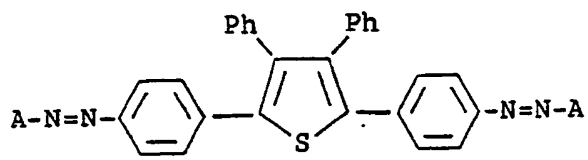
The same procedure as in Preparation Example 2 was conducted with the exception that 4.3 g of tetrakis(4-aminophenyl)thiophene and 24.5 g of iodobenzene were used, to obtain 6 g of yellow crystals [melting point = 228 to 232° C; λmax = 375 nm ($CHCl_3$)].

It was then confirmed by elemental analysis and from a molecular ion peak at 889(M+) in FD-MASS that the product was Exemplary Compound No. 27.

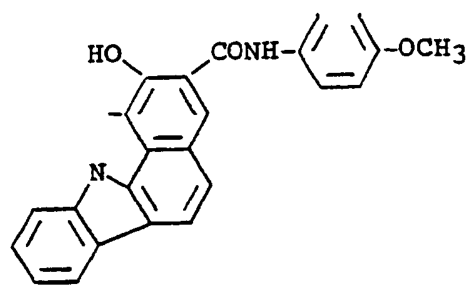
Results of Elemental Analysis (%)				
	C	H	N	S
Calcd.	86.33	5.34	5.30	3.03
Found	86.62	5.08	5.04	2.89

Example 1

In a ball mill, 0.5 g of polyester resin (made by Toyobo Co., Ltd.; trade name "Bylon 200"), 0.5 g of a diazo dye (CG-1) represented by the structural formula



wherein A is a group having the formula



and Ph is a phenyl group,
and 50 g of tetrahydrofuran were ground and mixed, and an aluminum plate was coated with the obtained dispersion by the use of a wire bar. Afterward, the coated plate was dried at 80 °C for 20 minutes to form a charge-generating layer having a thickness of about 0.5 µm.

This charge-generating layer was then coated by the use of a wire bar with a solution in which 1 g of Exemplary Compound No. 8, 1 g of polyester resin (trade name "Bylon 200"; made by Toyobo Co., Ltd.) were dissolved in 10 g of chloroform. The layer was afterward dried at 80 °C for 30 minutes to form a charge-transporting layer thereon having a thickness of about 18 µm, thereby preparing a laminate type photoreceptor as shown in Fig. 2.

The photoreceptor was electrified by corona discharge of 6 KV from an electrostatic copy paper test device (made by Kawaguchi Denki Seisakujo Co., Ltd.; model EPA-8100), and at this time, surface potential V0 was measured. Afterward, the photoreceptor was allowed to stand in a dark place for 2 seconds, and at this time, a surface potential V_2 was measured. In succession, the spcimen was irradiated with light from a halogen lamp (color temperature = 2,856 °K) so that the surface illuminance of the photoreceptor might be 5 lux, and a period of time which was taken until the surface potential attained a level of 1/2 of V_2 was measured. From measurements, the value of a half-life exposure $E_{1/2}$ (lux•sec) was then calculated. Furthermore, after 10 seconds were elapsed from the start of the light irradiation, a surface potential V_{12}, i.e., a residual potential was measured. Afterward, the operation of an electrification and an exposure were repeated 1,000 times.

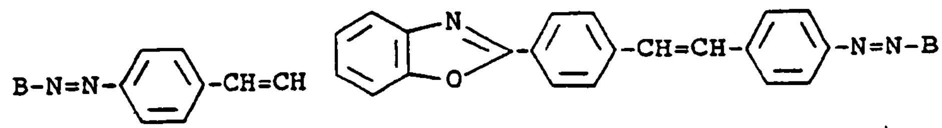
Examples 2 to 6

The same procedure as in Example 1 was repeated with the exception that charge-transporting materials were changed to prepare photoreceptors, and measurements were done for the same items. The

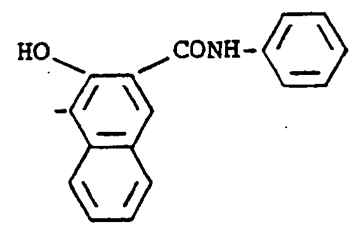
used charge-transporting materials and the measured results are set forth in Table 2.

Example 7

The same procedure as in Example 1 was conducted with the exception that a diazo dye (CG-2) represented by the following structural formula was used as a charge-generating material to prepare a photoreceptor, and measurements were done for the same items:



wherein B is a group having the formula:

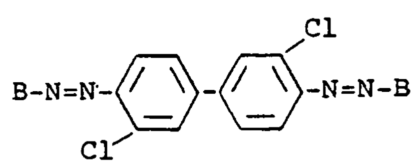


Examples 8 to 12

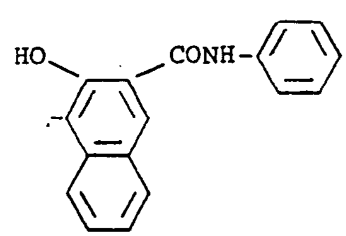
The same procedure as in Example 2 was conducted with the exception that the charge-transporting material was changed to prepare photoreceptors, and measurements were then made for the same items. The used charge-transporting matrials and the measured results are set forth in Table 2.

Example 13

The same procedure as in Example 1 was conducted with the exception that a disazo dye (CG-3) represented by the structural formula



wherein B is a group having the formula



was employed as a charge-generating material to prepare a photoreceptor, and measurements were then made for the same items.

Example 14

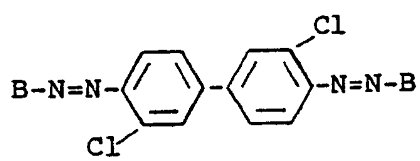
The same procedure as in Example 1 was conducted with the exception that τ-phthalocyanine (CG-4) was used as a charge-generating material, to prepare a photoreceptor, and measurements were then made for the same items.

Examples 15 to 90

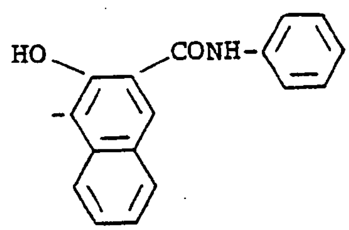
Following the manner of Example 1 with the exception that other charge-generating materials and charge-transporting materials were used, photoreceptors were prepared, and measurements were then made. As charge-generating materials, there were used azo compounds represented by the general formulae (II), (III) and (IV). Combinations of the used charge-generating materials and charge-transporting materials are set forth in Table 2. In this table, the used charge-generating materials are shown by symbols of the general formulae and the above-mentioned couplers.

Comparative Example 1

The same procedure as in Example 1 was conducted with the exception that disazo dye (CG-3) represented by the structural formula



wherein B is a group having the formula



was used as a charge-generating material and 2,5-bis(4-diethylaminophenyl)-1,3,4-oxadiazole (CT-1) was used as a charge-transporting material, to prepare a photoreceptor, and the operation of electrification exposure was repeated 1,000 times.

The measured results of Examples 1 to 90 and Comparative Example 1 are set forth in Table 2.

Table 2 (I)

Example	Charge-Generating Material	Charge-Transporting Material	Number of Repeated Operation	V_0(V)	V_2(V)	V_{12}(V)	$E_{1/2}$ (lux·sec)
Example 1	CG-1	Compound No. 8	1	-1120	-1080	0	1.2
			1000	-1060	-1010	0	1.3
Example 2	do	Compound No. 7	1	-1004	-980	0	2.0
			1000	-990	-970	-1	2.0
Example 3	do	Compound No. 3	1	-1210	-1130	-1	2.2
			1000	-1220	-1120	-2	2.6
Example 4	do	Compound No. 14	1	-990	-940	-1	2.0
			1000	-940	-900	-1	2.8
Example 5	do	Compound No. 21	1	-1310	-1270	0	3.6
			1000	-1290	-1200	0	4.2
Example 6	do	Compound No. 27	1	-1230	-1150	-1	2.8
			1000	-1220	-1130	-1	3.1
Example 7	CG-2	Compound No. 8	1	-980	-965	0	2.0
			1000	-970	-950	0	2.4
Example 8	do	Compound No. 7	1	-980	-950	0	2.3
			1000	-970	-945	0	2.4
Example 9	do	Compound No. 3	1	-995	-960	-2	2.4
			1000	-940	-925	-2	3.1
Example 10	do	Compound No. 14	1	-1130	-1065	0	2.1
			1000	-1085	-1000	0	2.2
Example 11	do	Compound No. 21	1	-1015	-980	-1	1.8
			1000	-975	-940	-2	1.9

Table 2 (II)

Example	Charge-Generating Material	Charge-Transporting Material	Number of Repeated Operation	V_0(V)	V_2(V)	V_{12}(V)	$E_{1/2}$ (lux•sec)
Example 12	CG-2	Compound No. 27	1 1000	-1130 -1080	-1065 -1010	0 -2	3.2 4.9
Example 13	CG-3	Compound No. 8	1 1000	-815 -810	-795 -770	-1 -2	1.8 2.1
Example 14	CG-4	Compound No. 8	1 1000	-855 -840	-820 -800	-3 -3	2.3 2.6
Example 15	(II)-(A-1)	Compound No. 7	1 1000	-1105 -1110	-950 -940	0 -1	2.5 2.5
Example 16	do	Compound No. 8	1 1000	-1170 -1115	-1100 -1060	-1 -1	2.1 2.5
Example 17	do	Compound No. 24	1 1000	-1150 -1100	-1090 -1060	0 0	2.4 3.1
Example 18	do	Compound No. 30	1 1000	-1220 -1150	-1170 -1100	-2 -5	3.4 3.9
Example 19	(II)-(A-9)	Compound No. 7	1 1000	-990 -980	-940 -935	-1 -1	2.2 2.2
Example 20	do	Compound No. 8	1 1000	-1150 -1110	-1070 -1020	0 -1	2.3 3.8
Example 21	do	Compound No. 24	1 1000	-1170 -1100	-1110 -1050	-1 -3	2.8 3.6
Example 22	do	Compound No. 30	1 1000	-1150 -1095	-1070 -1030	-2 -3	3.6 4.4

Table 2 (III)

Example	Charge-Generating Material	Charge-Transporting Material	Number of Repeated Operation	V_0(V)	V_2(V)	V_{12}(V)	$E_{1/2}$ (lux·sec)
Example 23	(II)-(A-21)	Compound No. 7	1	-1010	-980	-1	2.5
			1000	-1000	-980	-1	2.7
Example 24	do	Compound No. 8	1	-1190	-1120	0	2.0
			1000	-1120	-1050	0	2.6
Example 25	do	Compound No. 24	1	-1220	-1150	0	3.6
			1000	-1140	-1060	-2	4.4
Example 26	do	Compound No. 30	1	-1270	-1200	-1	3.2
			1000	-1180	-1100	-3	3.9
Example 27	(II)-(A-49)	Compound No. 7	1	-1140	-1010	0	2.1
			1000	-1150	-1000	-1	2.2
Example 28	do	Compound No. 8	1	-1210	-1140	0	2.2
			1000	-1160	-1110	-1	2.6
Example 29	do	Compound No. 24	1	-1220	-1145	-3	3.1
			1000	-1170	-1090	-5	3.8
Example 30	do	Compound No. 30	1	-1070	-1015	-1	2.4
			1000	-1020	-960	-2	3.5
Example 31	(II)-(A-120)	Compound No. 7	1	-980	-970	0	2.5
			1000	-985	-975	0	2.5
Example 32	do	Compound No. 8	1	-1110	-1050	-1	2.2
			1000	-1080	-1040	-2	2.6
Example 33	do	Compound No. 24	1	-1220	-1140	-3	3.4
			1000	-1120	-1040	-5	4.2

Table 2 (IV)

Example	Charge-Generating Material	Charge-Transporting Material	Number of Repeated Operation	V_0(V)	V_2(V)	V_{12}(V)	$E_{1/2}$ (lux•sec)
Example 34	(II)-(A-120)	Compound No. 30	1 1000	-1230 -1150	-1110 -1050	0 -1	2.6 3.6
Example 35	(III)-(A-1)	Compound No. 7	1 1000	-1220 -1240	-1150 -1170	0 0	2.0 2.0
Example 36	do	Compound No. 8	1 1000	-1110 -1070	-1060 -1010	-2 -3	2.4 2.9
Example 37	do	Compound No. 24	1 1000	-1040 -1010	-1000 -960	0 -2	2.9 3.5
Example 38	do	Compound No. 30	1 1000	-1210 -1140	-1150 -1080	-1 -2	2.8 3.1
Example 39	(III)-(A-9)	Compound No. 7	1 1000	-1000 -970	-920 -910	0 -1	2.1 2.2
Example 40	do	Compound No. 8	1 1000	-1250 -1200	-1185 -1140	0 -1	2.5 2.9
Example 41	do	Compound No. 24	1 1000	-1040 -970	-990 -910	0 0	3.2 4.2
Example 42	do	Compound No. 30	1 1000	-1160 -1090	-1110 -1020	-3 -5	3.4 4.5
Example 43	(III)-(A-21)	Compound No. 7	1 1000	-1230 -1200	-1150 -1110	0 -1	2.0 2.0
Example 44	do	Compound No. 8	1 1000	-1220 -1130	-1150 -1090	0 -1	2.2 2.4

Table 2 (V)

Example	Charge-Generating Material	Charge-Transporting Material	Number of Repeated Operation	V_0(V)	V_2(V)	V_{12}(V)	$E_{1/2}$ (lux·sec)
Example 45	(III)-(A-21)	Compound No. 24	1 1000	-1210 -1180	-1160 -1120	-1 -2	3.0 3.8
Example 46	do	Compound No. 30	1 1000	-970 -940	-920 -890	-3 -5	2.6 3.5
Example 47	(III)-(A-49)	Compound No. 7	1 1000	-1030 -990	-980 -910	-1 -1	2.1 2.2
Example 48	do	Compound No. 8	1 1000	-1180 -1150	-1120 -1080	0 0	2.0 2.6
Example 49	do	Compound No. 24	1 1000	-1120 -1080	-1085 -1020	-3 -5	3.6 4.4
Example 50	do	Compound No. 30	1 1000	-1240 -1190	-1155 -1080	0 -2	2.2 3.2
Example 51	(III)-(A-134)	Compound No. 7	1 1000	-1040 -1030	-940 -940	0 0	1.9 2.0
Example 52	do	Compound No. 8	1 1000	-1140 -1100	-1070 -1050	-1 -1	2.2 2.8
Example 53	do	Compound No. 24	1 1000	-1180 -1110	-1120 -1040	-2 -5	3.8 4.3
Example 54	do	Compound No. 30	1 1000	-1210 -1150	-1130 -1020	0 -1	2.9 3.6
Example 55	(IV)-(A-1)	Compound No. 7	1 1000	-995 -1010	-960 -970	0 0	1.8 1.9

Table 2 (VI)

Example	Charge-Generating Material	Charge-Transporting Material	Number of Repeated Operation	V_0(V)	V_2(V)	V_{12}(V)	$E_{1/2}$ (lux·sec)
Example 56	(IV)-(A-1)	Compound No. 8	1 1000	-1065 -1020	-990 -960	0 0	2.1 2.9
Example 57	do	Compound No. 24	1 1000	-1210 -1220	-1130 -1120	-1 -2	2.8 3.6
Example 58	do	Compound No. 30	1 1000	-1190 -1120	-1120 -1070	-2 -5	3.0 3.8
Example 59	(IV)-(A-9)	Compound No. 7	1 1000	-1020 -1000	-975 -970	-1 -1	1.9 1.9
Example 60	do	Compound No. 8	1 1000	-1230 -1220	-1150 -1130	-1 -1	2.8 3.1
Example 61	do	Compound No. 24	1 1000	-1180 -1170	-1165 -1150	0 0	2.0 2.4
Example 62	do	Compound No. 30	1 1000	-1090 -1060	-1065 -1030	-1 -3	3.6 4.8
Example 63	(IV)-(A-21)	Compound No. 7	1 1000	-980 -970	-965 -950	0 -1	2.4 2.6
Example 64	do	Compound No. 8	1 1000	-1100 -1050	-1040 -980	0 -1	2.0 2.4
Example 65	do	Compound No. 24	1 1000	-1220 -1180	-1150 -1120	-2 -5	2.8 3.9
Example 66	do	Compound No. 30	1 1000	-1090 -1010	-1020 -920	-3 -5	3.2 4.2

Table 2 (VII)

Example	Charge-Generating Material	Charge-Transporting Material	Number of Repeated Operation	V_0(V)	V_2(V)	V_{12}(V)	$E_{1/2}$ (lux•sec)
Example 67	(IV)-(A-49)	Compound No. 7	1	-1170	-1140	-1	1.7
			1000	-1080	-1030	-1	1.8
Example 68	do	Compound No. 8	1	-1210	-1150	0	2.2
			1000	-1190	-1130	-1	2.6
Example 69	do	Compound No. 24	1	-1200	-1165	0	2.9
			1000	-1170	-1125	0	3.3
Example 70	do	Compound No. 30	1	-990	-955	-1	3.6
			1000	-950	-930	-3	4.8
Example 71	(IV)-(A-53)	Compound No. 7	1	-1170	-1050	0	1.4
			1000	-1200	-1040	0	1.4
Example 72	do	Compound No. 8	1	-1150	-1100	0	1.8
			1000	-1095	-1050	0	2.2
Example 73	do	Compound No. 24	1	-980	-950	-2	2.8
			1000	-900	-880	-3	3.2
Example 74	do	Compound No. 30	1	-1020	-990	0	2.0
			1000	-940	-890	-2	3.2
Example 75	(IV)-(A-66)	Compound No. 7	1	-1040	-970	-1	1.0
			1000	-1050	-970	-1	1.0
Example 76	do	Compound No. 8	1	-1180	-1110	-3	3.8
			1000	-1120	-1070	-5	4.2
Example 77	do	Compound No. 24	1	-1240	-1180	0	2.7
			1000	-1170	-1085	-2	3.5

Table 2 (VIII)

Example	Charge-Generating Material	Charge-Transporting Material	Number of Repeated Operation	V_0(V)	V_2(V)	V_{12}(V)	$E_{1/2}$ (lux·sec)
Example 78	(IV)-(A-66)	Compound No. 30	1 1000	-1040 -975	-980 -920	-1 -1	3.7 4.2
Example 79	(IV)-(A-122)	Compound No. 7	1 1000	-1100 -1050	-1020 -1000	-1 -1	2.1 2.1
Example 80	do	Compound No. 8	1 1000	-1210 -1145	-1160 -1080	-1 -2	2.6 2.9
Example 81	do	Compound No. 24	1 1000	-1120 -1070	-1080 -1010	0 -3	3.3 3.7
Example 82	do	Compound No. 30	1 1000	-1020 -950	-970 -910	-1 -1	2.5 3.4
Example 83	(IV)-(A-153)	Compound No. 7	1 1000	-890 -900	-800 -800	-1 -1	0.8 0.8
Example 84	do	Compound No. 8	1 1000	-1120 -1100	-1010 -1000	0 0	0.9 0.9
Example 85	(IV)-(A-154)	Compound No. 7	1 1000	-1220 -1190	-1170 -1090	0 -1	1.1 1.2
Example 86	do	Compound No. 8	1 1000	-1030 -1050	-960 -970	-1 -1	1.1 1.1
Example 87	(IV)-(A-155)	Compound No. 7	1 1000	-1110 -1100	-1010 -1000	0 -1	1.2 1.2
Example 88	do	Compound No. 8	1 1000	-990 -980	-900 -870	-1 -1	1.1 1.1

Table 2 (IX)

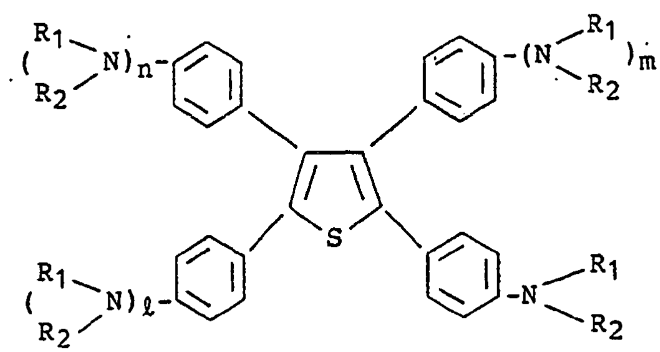
Example	Charge-Generating Material	Charge-Transporting Material	Number of Repeated Operation	V_0(V)	V_2(V)	V_{12}(V)	$E_{1/2}$ (lux•sec)
Example 89	(IV)-(A-59)	Compound No. 7	1	-1170	-1050	0	1.5
			1000	-1150	-1010	-1	1.6
Example 90	do	Compound No. 8	1	-940	-890	0	1.3
			1000	-950	-890	0	1.4
Comp. Ex. 1	CG-3	CT-1	1	-1040	-950	-5	5.6
			1000	-975	-890	-17	16.2

Examples 91 to 99

The photoreceptors of the present invention prepared in Examples 1, 15, 16, 35, 36, 55, 56, 83 and 84 were used in a commercially available electrophotographic copier, and copying operation was then made. In consequence, it was found that these photoreceptors could provide fog-free clear images which were faithful to an original even on the ten thousandth sheet of the copies.

Claims

1. A tetraphenylthiophene derivative represented by the general formula (I)



(I)

wherein each of R_1 and R_2 is an alkyl group, an aralkyl group or an aryl group which may be substituted, and R_1 and R_2 may be linked with each other to form a ring together with a nitrogen atom; and each of ℓ, m and n is an integer of 0 or 1 and is selected to meet the condition formula $\ell \geq m \geq n$.

2. A tetraphenylthiophene derivative as claimed in Claim 1 wherein each of R_1 and R_2 in the formula (I) is a phenyl group which may be substituted or a naphthyl group which may be substituted.

3. A tetraphenylthiophene derivative as claimed in Claim 1 wherein each of R_1 and R_2 in the formula (I) is a phenyl group or a naphtyl group which may be substituted by one or more of halogen atoms, alkyl groups having 1 to 8 carbon atoms, alkoxy groups having 1 to 5 carbon atoms, carboxylate groups having 1 to 6 carbon atoms, aralkyl groups having 7 to 10 carbon atoms, phenyl groups and/or naphthyl groups.

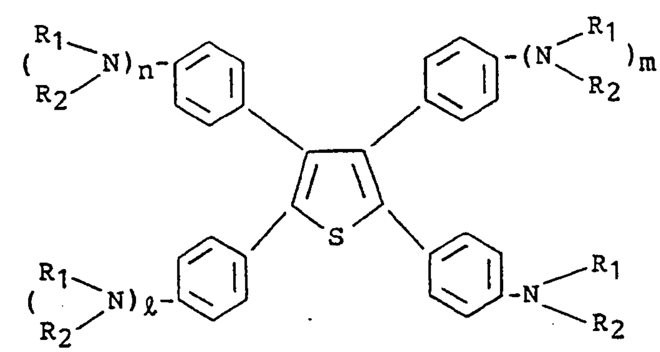
4. A tetraphenylthiophene derivative as claimed in Claim 3 wherein ℓ, m and n in the general formula (I) are 0.

5. A tetraphenylthiophene derivative as claimed in Claim 3 wherein ℓ is 1, and m and n are 0.

6. A tetraphenylthiophene derivative as claimed in Claim 3 wherein ℓ and m are 1, and n is 0.

7. A tetraphenylthiophene derivative as claimed in Claim 3 wherein ℓ, m and n are 1.

8. An electrophotographic photoreceptor which is composed of an electrically conductive base and a photosensitive layer thereon containing a charge-generating material and a charge-transporting material, characterized in that said charge-transporting material comprises a tetraphenylthiophene derivative represented by the general formula (I)



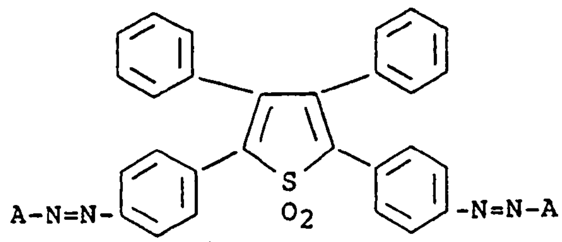
(I)

wherein each of R_1 and R_2 is an alkyl group, and an aralkyl group or an aryl group which may be substituted, R_1 and R_2 may be linked with each other to form a ring together with a nitrogen atom; and each of ℓ, m and n is an integer of 0 or 1 and is selected to meet the condition formula $\ell \geq m \geq n$.

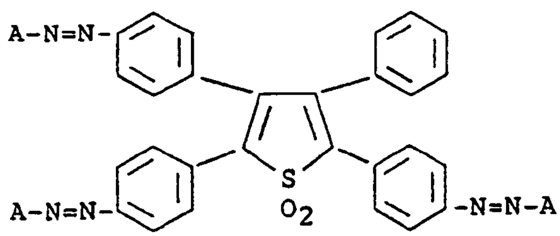
9. An electrophotographic photoreceptor as claimed in Claim 8 wherein the photosensitive layer comprises two layers, one of which contains a charge-generating material and the other of which contains a charge-transporting material.

10. An electrophotographic photoreceptor as claimed in Claim 8 wherein each of R_1 and R_2 in the formula (I) is a phenyl group or a naphtyl group which may be substituted by one or more of halogen atoms, alkyl groups having 1 to 8 carbon atoms, alkoxy groups having 1 to 5 carbon atoms, carboxylate groups having 1 to 6 carbon atoms, aralkyl groups having 7 to 10 carbon atoms, phenyl groups and/or naphthyl groups.

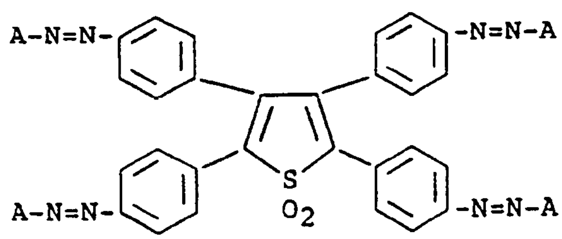
11. An electrophotographic photoreceptor as claimed in Claim 8 wherein said charge-generating material is an azo compound represented by the general formula (II), (III) or (IV)



(II)



(III)



(IV)

wherein A in the formulae (II), (III) and (IV) is a coupler residuum.

FIG.1

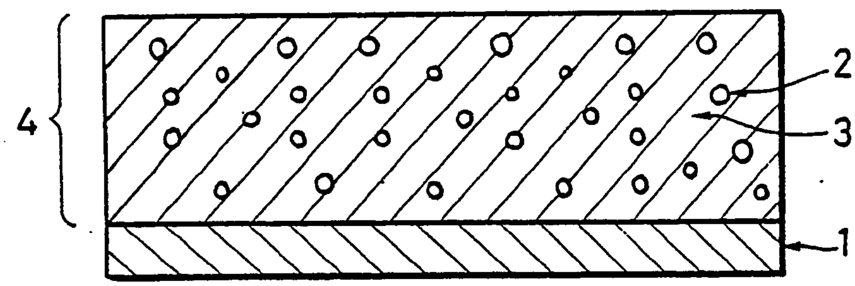
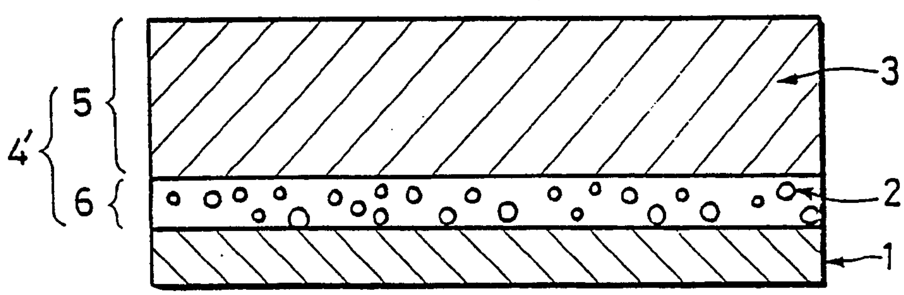


FIG.2



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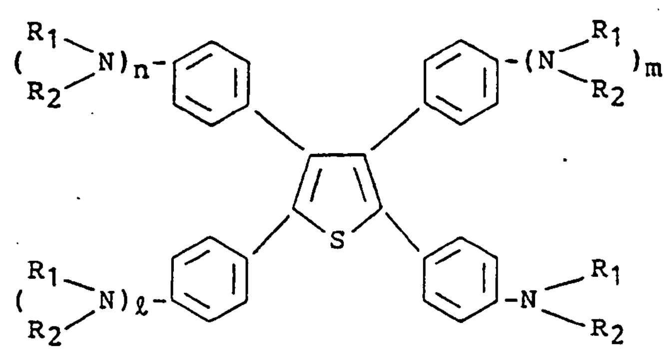
(54) Tetraphenylthiophene derivative and electrophotographic photoreceptor containing same.

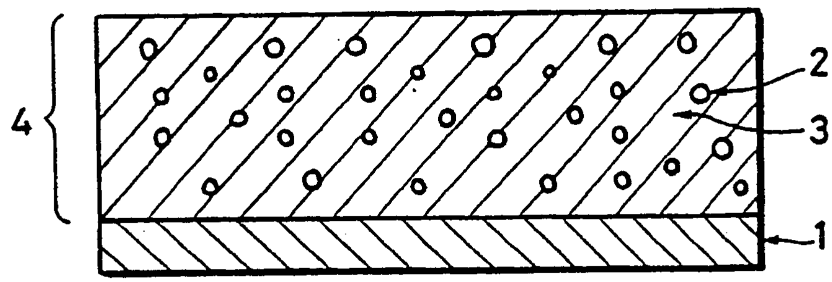
(57) There are here provided a novel tetraphenylthiophene derivative represented by the general formula



wherein each of R_1 and R_2 is an alkyl group, an aralkyl group or an aryl group which may be substituted, and R_1 and R_2 may be linked with each other to form a ring together with a nitrogen atom; and each of ℓ, m and n is an integer of 0 or 1 and is selected to meet the condition formula $\ell \geq m \geq n$;

and an electrophotographic photoreceptor which is composed of an electrically conductive base and a photosensitive layer thereon containing the aforesaid tetraphenylthiophene derivative as a charge-transporting material, and a charge-generating material, preferably a specific azo compound.

FIG.1



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EUROPEAN SEARCH REPORT

Application Number

EP 88 31 0720

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	CHEMICAL ABSTRACTS, vol. 107, no. 14, 5th October 1987, pages 585-586, abstract no. 124534z, Columbus, Ohio, US; & JP-A-62 47 053 (FUJI PHOTO FILM CO., LTD) 28-02-1987 * Abstract, especially formula II * ---	1,8,9, 11	C 07 D 333/20 G 03 G 5/06
P,Y	EP-A-0 270 685 (MITSUI TOATSU CHEMICALS, INC.) * Claims * ---	1,8,9, 11	
P,Y	CHEMICAL ABSTRACTS, vol. 109, no. 24, 12th December 1988, page 8, abstract no. 211606j, Columbus, Ohio, US; & JP-A-63 91 382 (ASAHI GLASS CO., LTD) 22-04-1988 * Abstract * -----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)
C 07 D 333/00 G 03 G 5/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18-09-1990	CHOULY J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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